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ABSTRACT

Despite efforts to improve the quality and equity of science, mathematics, engineering, and technology (SMET) education at all educational levels, the nation remains at risk of losing its competitive edge. This report presents the findings of a special panel convened for two purposes: (1) to review federal programs in SMET education at all levels; and (2) to provide an assessment of federal program evaluation efforts. The panel's recommendations emphasize improved management and coordination of programs, more balanced distribution of existing funds, and comprehensive evaluation. Presented first are the panel's principal findings and recommendations related to each of the two types of issues identified by the panel: those that apply to SMET education as a whole and those that apply to specific areas of SMET education. (PR)

The Federal Investment in Science, Mathematics, Engineering, and Technology Education: *Where Now? What Next?*

Report of the Expert Panel for the Review of Federal Education Programs in Science, Mathematics, Engineering, and Technology

for the

Federal Coordinating Council for Science, Engineering and Technology

Committee on Education and Human Resources

June 1993

The Federal Investment in Science, Mathematics, Engineering, and Technology Education: *Where Now? What Next?*

Executive Summary

Expert Panel

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Executive Summary

A decade has passed since *A Nation At Risk* sounded the first warning of a crisis in American education. In the intervening years, valiant efforts to define and stem the crisis have been made, especially in the crucial areas of science, mathematics, engineering, and technology (SMET), where numerous public and private efforts are under way. In 1993 alone, the Federal Government will spend at least $2.2 billion on education programs specifically targeting SMET fields. Total Federal spending on SMET education—a figure that includes related components of numerous Federal programs that are *not* targeted specifically toward SMET education—may be approximately $24 billion in 1993.

Despite efforts to improve the quality and equity of SMET education at all educational levels, the nation remains at risk of losing its competitive edge. Recognizing the need to enhance the coordination of Federal SMET programs, in January 1993 the Committee on Education and Human Resources (CEHR) of the Federal Coordinating Council for Science, Engineering and Technology (FCCSET) implemented a five-year strategic plan. Among the first of the plan's agenda items was the appointment of an Expert Panel charged with two tasks: (1) to conduct a broad review of Federal programs in SMET education, and (2) to assess Federal program evaluation efforts. This report presents the findings of the Panel, along with its recommendations to bring about true reform in Federal SMET education programming. The recommendations emphasize improved management and coordination of programs, more balanced distribution of existing funds, and comprehensive program evaluation. Presented first are the Panel's principal findings and recommendations, followed by more specific findings and recommendations related to each of the Panel's two charges. For a selected bibliography of the reference materials consulted during the preparation of this report, see the *Sourcebook* that accompanies the Expert Panel's report.

"We are involved in two wars in this country: a civil war between the underclass and the privileged in our major urban centers and a global war to compete for economic survival. The key to resolving both of these conflicts is education."

Karl S. Pister
Expert Panel Co-Chair

A Need for Balance

"Our educational effort has not been raised to the plateau of the age we live in . . . .We must measure it not by what it would be easy and convenient to do, but by what it is necessary to do in order that the nation may survive and flourish."

W. Lippman. *Atlantic Monthly*, May 1954

Analysis of Federal programming for science, mathematics, engineering, and technology education—the Panel's first charge—confirms a distressing truth: coordination of Federal programs across agencies and governmental levels and with the private sector is insufficient. In addition, Federal core programs in SMET education lack balance and coherence. Although the Panel applauds the ongoing work of the interagency Committee on Education and Human Resources for its coordination efforts, the Panel members found that its role needs to be strengthened.

To resolve this problem, the Panel recommends that the Committee develop a management plan based on its goals for SMET education. An effective plan would coordinate Federal efforts across agencies and education levels, and it would emphasize program evaluation and dissemination. Active and continuous dialogue among all governmental players in SMET education is vital and must form the basis of a new Federal culture of communication and cooperation.

The Panel's assessment of Federal program evaluation efforts—its second charge—reveals similarly sobering findings. In brief, the Panel found that current Federal spending on SMET education is not guided by assessments of national need, that few Federal programs have been thoroughly evaluated to determine their effectiveness, and that funding for evaluation and evaluation personnel is extremely limited. In addition, the Panel learned that current evaluation practices are often inadequate for the purposes of improving programs, making informed decisions about program retention or expansion, and providing for real accountability.

To address these issues, the Panel recommends improved national needs assessment. Rigorous evaluation criteria must be adopted to ensure that programs meet identified needs. Evaluation results should constitute the knowledge base for program planning, revision, and replication within and among all Federal agencies.

The Federal Investment Portfolio

In conducting a broad review of Federal programs in SMET education, the Panel identified five major needs that cut across all levels of education: to increase participation of students from underrepresented populations; to increase research on the effective use of technology for SMET education; to disseminate exemplary, effective models; to improve instructor preparation—at all educational levels—for teaching; and to encourage research on teaching and learning to improve instruction and curricula.

In reviewing issues that relate specifically to prekindergarten through grade 12, the Panel identified a need to establish the following guidelines: instructional materials and other projects targeted to these students should be developed with the benefit of all relevant SMET education research; teacher enhancement programs should shift their focus away from short-term experiences

toward longer term continuous enrichment necessary for excellence; and mentoring should become an important tool in teacher education through greater emphasis on training teacher leaders. In addition, the Panel urged the provision of additional SMET education support for low-income children, the establishment of national goals for technology education, and the funding of improvements in technology education curricula.

To improve SMET education at the undergraduate level, the Expert Panel recommends efforts to enhance the teaching practices of faculty and the development of incentives to encourage colleges and universities to place greater emphasis on learning and instruction. The Panel also recommends that support for programs to develop SMET courses for nonscience majors be increased, that newly developed courses be required to incorporate up-to-date knowledge about the disciplinary subject matter content of each course, and that effective ways to improve student learning be implemented.

"Public understanding of science needs to focus on more than just classrooms. Media and museum programs must become important parts of the community venture in learning."

Mary Budd Rowe
Expert Panel Co-Chair

At the graduate level, the Expert Panel recommends that federally sponsored faculty research grants truly support a well-rounded educational experience for graduate assistants. The Panel also recommends reallocation of funds to provide more support for students in professional, applied SMET areas and collaboration among Federal agencies to ensure that the availability and distribution of graduate student support is responsive to labor force needs and emerging and interdisciplinary fields of SMET.

In support of community colleges and continuing education programs, the Panel urges greater collaboration among two- and four-year colleges in support of nontraditional students and students who are underrepresented in SMET disciplines, as well as cooperation among high schools, two-year colleges, four-year colleges, and industry in the interests of enhancing technical education and training programs. The Expert Panel also recognizes the benefits of greater public understanding of SMET issues, and it recommends development of a coordinated, ongoing strategic plan for increasing public understanding.

The Role of Evaluation

After examining the Federal program evaluation activities, the Expert Panel concluded that evaluations of SMET education programs conducted to date are inadequate and, to a great extent, the effects and effectiveness of much of the Federal investment remain unexamined. To remedy this situation, the Panel recommends the implementation of the evaluation component of the Federal Strategic Plan for SMET education and continued monitoring by the Committee on Education and Human Resources. In addition, the Panel recommends that Federal agencies be required to show significant progress in planning and implementing evaluations by the end of fiscal year 1994; that evaluation efforts be prioritized and coordinated

". . . the United States simply does not have the luxury of supporting the wrong programs or failing to support the right ones."
Expert Panel

across agencies; that the agencies implement standards of evaluation practice, using as a base those standards currently being revised by the Joint Committee on Standards of Educational Evaluation; and that evaluations within and across programs be based on a systems view, that is, a view that considers key factors and influences on program operation and on short- and long-term outcomes.

To support the comprehensive, cross-agency evaluation effort recommended by the Panel, the Panel suggests development of a plan to explore the types of assessment required for a SMET curriculum that fosters critical thinking and measures the curriculum's effects. It also recommends that funding for evaluation be considered a priority budget item by the agencies involved.

Finally, the Expert Panel recommends that each agency establish a minimum core set of statistical indicators to be collected and synthesized for similar types of programs; that the indicators be augmented by objective, systematic evaluation studies; and that Federal agencies encourage local programs to use evaluation information for program decision making.

The findings of the Expert Panel and the resulting recommendations are designed to help improve the Federal effort to educate Americans in science, mathematics, engineering, and technology. These are areas upon which the civic and economic well-being of this country depend. This nation cannot afford to continue supporting education programs whose outcomes are untested or unknown. The Federal Government can and should play a leadership role in science, mathematics, engineering, and technology education. The Panel recommends that Federal SMET education programs be understood and managed as a "portfolio of investments," with the ultimate goals being improved quality of life for all Americans and greater prosperity for this nation.

The Federal Investment in Science, Mathematics, Engineering, and Technology Education: *Where Now? What Next?*

Report of the
Expert Panel for the
Review of Federal
Education Programs
in Science, Mathematics,
Engineering, and
Technology

to the

Federal Coordinating
Council for Science,
Engineering and
Technology

Committee on Education
and Human Resources

June 1993

Dr. Luther S. Williams
Acting Chair
Federal Coordinating Council
for Science, Engineering and
Technology, Committee on
Education and Human Resources

Dear Luther:

We are pleased to transmit to you *The Federal Investment in Science, Mathematics, Engineering, and Technology Education: Where Now? What Next?* report in fulfillment of the charge to the Expert Panel for the Review of Federal Education Programs in Science, Mathematics, Engineering, and Technology.

A decade ago, the report *A Nation At Risk* warned that the educational foundations of our society were being eroded. Today, our report warns that—although some important first steps have been taken—Federal agencies currently are not effectively working together to do all they can and must do to reverse the "rising tide of mediocrity."

The central theme of the report is that Federal agency efforts in science, mathematics, engineering, and technology education should be viewed and managed as a portfolio of investments in our nation s future. This portfolio needs to be skillfully shaped, maintained, and cultivated. This requires the development of a new culture of coordination and cooperation among Federal agencies and, most important, a commitment to rigorous, continuous program evaluation and improvement.

It has been our pleasure to have served our nation together with such distinguished colleagues.

Respectfully,

Karl S. Pister
Co-Chair
Expert Panel

Mary Budd Rowe
Co-Chair
Expert Panel

NATIONAL SCIENCE FOUNDATION
4201 WILSON BOULEVARD
ARLINGTON, VIRGINIA 22230

Honorable John H. Gibbons
Assistant to the President
for Science and Technology
Old Executive Office Building
Washington, D.C. 20500

Dear Jack:

It is with pleasure that I submit to you the report, *The Federal Investment in Science, Mathematics, Engineering, and Technology Education: Where Now? What Next?* This report was produced by an independent panel of experts chartered under the Federal Coordinating Council for Science, Engineering and Technology, Committee on Education and Human Resources.

The panel reviewed several hundred initiatives in science, mathematics, engineering, and technology education from 16 agencies; examined interagency policies and plans; and reviewed the status and role of program evaluation. The resulting product is this excellent report and sourcebook whose purpose is to guide future planning and interagency coordination in education.

The report reflects two central themes. First, although strides have been made to coordinate Federal science, mathematics, engineering, and technology education programs under the Committee on Education and Human Resources, a greater degree of coordination is necessary and desirable. Second, only 20 percent of Federal science, mathematics, engineering, and technology education programs have undergone rigorous evaluation for effectiveness. Program evaluation efforts should be accelerated, strengthened, and coordinated among the agencies.

I, like the members of the panel, share the view that government policies and programs can effectively promote national prosperity and the well-being of our people. The panel and its co-chairs have demonstrated remarkable leadership in completing their work so efficiently and competently. This report provides clear and valuable guidance to improve the Federal investment in science, mathematics, engineering, and technology education.

Sincerely,

Luther S. Williams

Luther S. Williams
Acting Chair
Committee on Education and
Human Resources

Acronyms

CD-ROM	Compact Disk - Read Only Memory
CEHR	Committee on Education and Human Resources
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of Interior
ED	Department of Education
EPA	Environmental Protection Agency
FCCSET	Federal Coordinating Council for Science, Engineering and Technology
HHS	Health and Human Services
NASA	National Aeronautic and Space Administration
NSF	National Science Foundation
SI	Smithsonian Institution
SMET	Science, Mathematics, Engineering, and Technology
USDA	U.S. Department of Agriculture

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Three smallest cover photos by Paul Potera.

The views expressed in this document are those of the individual panelists and do not necessarily reflect the views of the National Science Foundation or other Federal agencies.

"The nation that dramatically and boldly led the world into the age of technology is failing to provide its own children with the intellectual tools needed for the Twenty-First Century."

Educating Americans for the 21st Century. National Science Board Commission on Pre-College Education in Mathematics, Science, and Technology (1983)

Introduction

In 1983, *A Nation At Risk* jarred the national consciousness. Released by the Commission on Excellence in Education, the landmark report warned the American people that the nation was at risk of losing its competitive edge to countries with superior education systems.

Ten years later, America remains at risk. True, many heard the alarm sounded in *A Nation At Risk*, and many efforts have been made to turn the tide. Nevertheless, although some progress toward strengthening the quality of American education has been achieved, the goals set forth in the report continue to elude the nation's grasp. As noted at a 1993 conference commemorating the report's 10th anniversary, the recommendations have been implemented in a piecemeal fashion, missing the point that the system's many parts must work in concert if they are to work well. Commission member and Nobel Laureate Glenn Seaborg cautioned that, "We are at risk of becoming a Third World country, going downhill, losing our competitive edge in a high-tech society, and of our people being uneducated to the extent [that] they can't operate intelligently in a democratic society."

Today, more than ever, technological competence has become crucial to maintaining our nation's position as a leader in global affairs and to solidifying our position in the emerging global economy. This places a special responsibility on American educators to ensure that students at all educational levels gain exposure to and have opportunities to pursue high-quality science, mathematics, engineering, and technology (SMET) education. In fact, SMET education was a focal point in the National Education Goals established by the President and the nation's governors in 1990, and it continues to be a concern of many Federal and state agencies today.

Although Federal funding of SMET education constitutes only a small portion of the total dollars spent on education in this country, the Federal Government nevertheless has expended billions of dollars to bring about change and reform in SMET education. Still, the impact of current Federal efforts in SMET education remains unclear. A potpourri of programs has evolved. Federal expenditures are being made with too little overall planning and with inadequate evaluation. The resulting array of Federal programs boasts some excellent components, but its weaknesses and possible redundancies diminish its overall effectiveness.

Recognizing the need to better coordinate what now are mostly ad hoc Federal efforts to improve SMET education, the Committee on Education and Human Resources (CEHR) of the Federal Coordinating Council for Science, Engineering and Technology (FCCSET) devised a five-year strategic plan in January 1993. The plan, which is described in *Pathways to Excellence: A Federal Strategy for Science, Mathematics, Engineering, and Technology Education*,[1] is formulated on the premise that the Federal

". . . while we can take justifiable pride in what our schools and colleges have historically accomplished and contributed to the United States and the well-being of its people, the educational foundations of our society are presently being eroded by a rising tide of mediocrity that threatens our very future as a nation and a people."

A Nation At Risk, National Commission on Excellence in Education (1983)

"It is time for a new culture of interaction, communication, and coordination to be developed and sustained within and among all Federal agencies in the area of education."
Expert Panel

Government can best help the nation achieve and maintain leadership in science, mathematics, engineering, and technology by furthering SMET education reform. A strong Federal contribution to SMET education requires planning, funding, program delivery, and program evaluation beyond individual agency authority. It is time for a new culture of interaction, communication, and coordination to be developed and sustained within and among all Federal agencies in the area of education.

Among the first actions taken by the Committee on Education and Human Resources under the 1993 Strategic Plan was the creation of an Expert Panel. Supported by the National Science Foundation and co-chaired by Dr. Karl S. Pister, Chancellor of the University of California, Santa Cruz, and Dr. Mary Budd Rowe of Stanford University, the 15-member Panel undertook the following actions for the Committee:

- A broad review of Federal programs in science, mathematics, engineering, and technology education at all levels (prekindergarten through graduate school).
- An assessment of Federal program evaluation efforts.

This report, *The Federal Investment in Science, Mathematics, Engineering, and Technology Education: Where Now? What Next?*, presents the Panel's findings and recommendations relating to both charges. The report was drafted by the Panel members, who were assigned topics according to their areas of expertise. The final report was compiled by Dr. Frances Lawrenz, Special Assistant to the Panel, under the direction of the co-chairs. For more information on the mission of the Expert Panel, its membership, and FCCSET CEHR, see the appendix. The report was assembled with the help and cooperation of the 13 Federal agencies with SMET education-related functions. For a selected bibliography of the reference materials consulted during the preparation of this report, see the *Sourcebook* that accompanies this report.

In addition to this introductory section and a brief conclusion, this report has three major sections. "A Need For Balance" outlines the two principal findings of the Expert Panel—one related to its review of Federal programs and the other to the state of program evaluation. It also contains broad recommendations for managing and protecting the nation's investment in SMET education.

[1] *Pathways to Excellence: A Federal Strategy for Science, Mathematics, Engineering, and Technology Education. U.S. Science, Mathematics, Engineering, and Technology Education Strategic Plan, FY 1994-FY 1998*, Committee on Education and Human Resources

"The Federal Investment Portfolio" addresses the first charge to the Panel, i.e., to perform a review of Federal SMET education programs. The Panel feels strongly that Federal SMET education programs must be managed as a "portfolio of investments" in our nation's future. The recommendations contained in this section are intended to improve the management and coordination of programs and the distribution of existing funds.

Finally, "The Role of Evaluation" addresses the second charge to the Panel, i.e., to review Federal evaluation activities. The recommendations contained in this section are intended to outline a Federal framework for evaluation of SMET education programs, increase their frequency, and improve their quality.

The findings and recommendations offered here begin the process of Federal program assessment. The Panel's mandate was to provide a limited review based on existing data. A more comprehensive review will require in-depth, long-term investigation.

"We must strive to meet the developmental needs of each individual in our society to derive the maximum benefit from the potential capabilities of all members of our society."

LEARNING to Meet the Science and Technology Challenge, President's Council of Advisors on Science and Technology (1992)

A Need For Balance

In 1983, *A Nation At Risk* found little coordination in American education policy. Ten years later, the Carnegie Commission report, *Science, Technology, and Government for a Changing World*,[2] found similar problems at the Federal level. The present report confirms these findings; further, it examines current Federal programming within the context of national needs. The Expert Panel firmly believes that the United States simply does not have the luxury of supporting the wrong programs or failing to support the right ones.

In addition to the more specific findings and recommendations set out in the sections that follow, the Expert Panel identified two principal findings and associated recommendations related to each of its two charges. Although these two findings and recommendations are broader in scope than others in this report, they do not summarize or replace the specific findings and recommendations established by the Panel.

Principal Findings

The principal findings address the Panel's specific charges: to broadly review the Federal programs in SMET education and to assess Federal evaluation efforts.

i. ***The Investment Portfolio.*** *The Federal commitment of dollars to SMET education is significant. In 1993 alone, $2.2 billion in Federal funds will be expended on nearly 300 "core programs" constituted solely to support SMET education (see Figure 1). If the SMET*

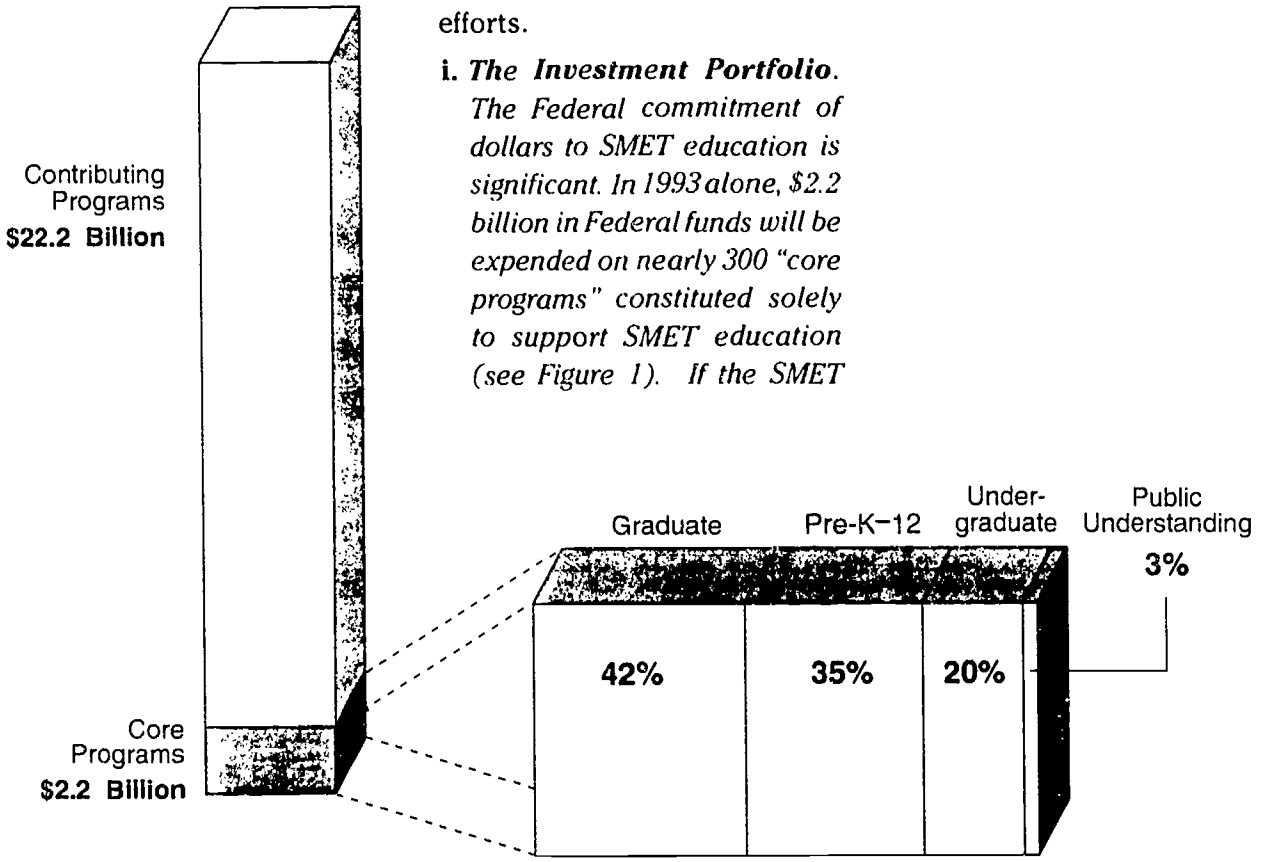


Figure 1

Federal Investment in SMET Education

[2] *Science, Technology, and Government for a Changing World. The Concluding Report of the Carnegie Commission on Science, Technology, and Government.* Carnegie Commission on Science, Technology, and Government (New York, NY: Carnegie Commission, 1993).

education components of Federal "contributing programs" are included, this sum could be as large as $24.4 billion. Unfortunately, though, the Federal portfolio of core programs is unbalanced and lacks coherence. This situation is the result of varying agency missions, a decentralized congressional resource allocation process, and an overall lack of coordination and planning. The lack of coherence and balance in programs makes it next to impossible to maintain fidelity to the overarching national goals for science, mathematics, engineering, and technology education. Furthermore, far more is spent on SMET education by the combination of state and local authorities and private foundations. Many of the conclusions in this report also apply to state, local, and private efforts.

ii. ***Evaluation of the Investment.*** *Current SMET education evaluation practices are often inadequate for the purposes of improving programs, making informed decisions about program retention or expansion, or providing for real accountability. Funding for evaluation ($8 million) constitutes less than one-half of 1 percent of core Federal funding for SMET education, and in fact, just 20 percent of the approximately 300 core Federal SMET programs have been evaluated (see Figure 2).*

Principal Recommendations

The principal recommendations presented below also address the Panel's two-part charge.

A. <u>Manage the Investment</u>: The work of the Committee on Education and Human Resources and its Federal Strategic Plan outlined in *Pathways to Excellence* constitute a strong beginning—but a stronger *management* plan is crucial. The management plan should designate lead agencies for Federal initiatives in particular areas and recommend the merger or phasing out, as well as the development, of new programs as appropriate. This management plan must treat Federal SMET education programs like a portfolio of investments by ensuring that a greater proportion of agency programs (1) are aligned with overall Strategic Plan goals, (2) are coordinated across agencies and education levels, (3) use effective strategies for dissemination, (4) include appropriate evaluations, and (5) promote equity. Active and continuous dialogue within and among agencies (dialogue that includes state, local, and private-sector players when appropriate) must be based on a renewed commitment to effective communication and active coordination of effort.

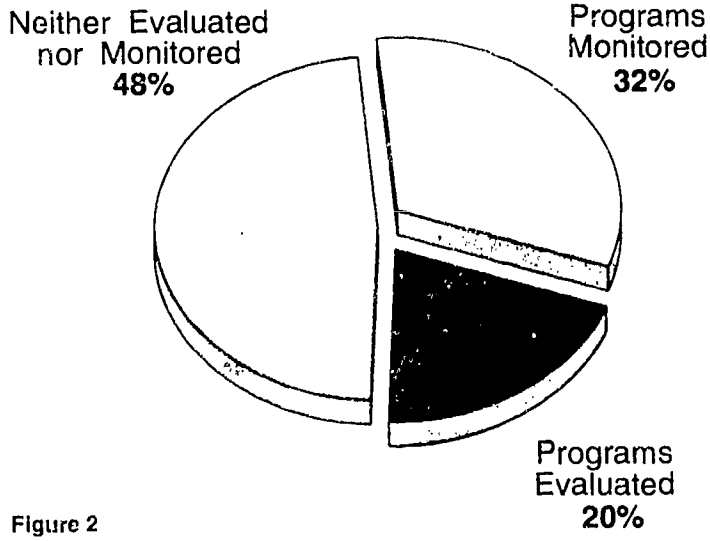


Figure 2
Evaluation of CORE Programs

B. Improve the Investment: **National needs assessment should underlie program initiatives in science, mathematics, engineering, and technology education. Programs should be evaluated rigorously for effectiveness in meeting identified needs.** Evaluation results should be used as a basis for planning and revising programs and should be shared with other Federal agencies. The sharing of evaluations and evaluation results among agencies prevents duplication and wasted effort, opens opportunities for collaboration across agencies, and helps to build more successful programs within agencies.

As it reviewed and discussed Federal SMET programs, the Expert Panel identified two types of issues: those that apply to SMET education as a whole and those that apply to specific areas of SMET education. This section of the report presents the findings and recommendations related to both types of issues. Although the issues applying to SMET education as a whole are presented first, those pertaining to specific areas are equally important and pressing. Note: Throughout subsequent sections of this report, the Panel's findings are represented in *italic* type; recommendations are depicted in **bold.**

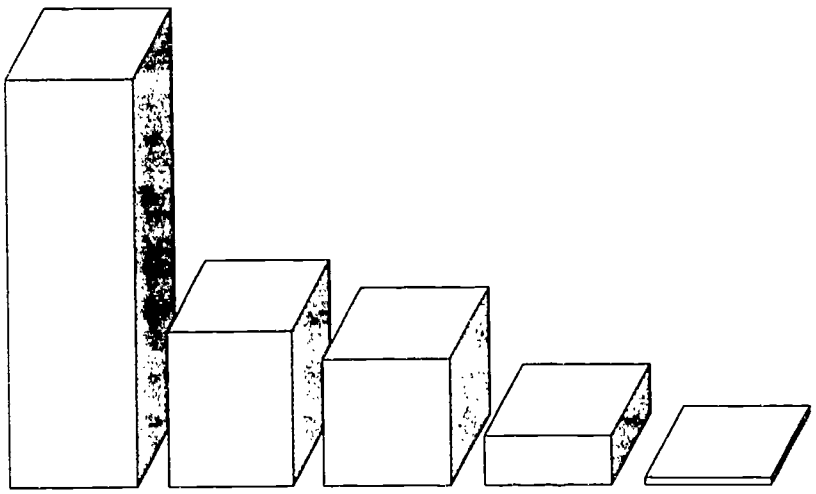
The Federal Investment Portfolio

Issues in SMET Education

Findings and Recommendations

1.1 The Federal Government now spends more than $236 million on core programs targeted toward underrepresented groups. Approximately 58 percent ($138 million) of this expenditure targets racial or ethnic minorities (see Figure 3). Millions of additional Federal dollars are spent on underrepresented groups through nontargeted programs.

Despite continued Federal expenditure, the percentage of minority students studying SMET subjects (particularly at the graduate level) remains abysmally low. In engineering, the physical sciences, and mathematics, women are also significantly underrepresented. The problem of poor retention by underrepresented populations in SMET undergraduate and graduate study cannot be viewed apart from the troubling fact that inadequate preparation and/or lack of resources in SMET often occurs long before these students reach college age. The programs that demonstrate the most success in improving participation of underrepresented groups are those that provide early support and bridge one education level to the next. However, more Federal dollars per student are spent at the college level than at the prekindergarten through 12th grade (pre-K–12) level.



Note: Percents reported total more than 100 percent because some programs target multiple underrepresented audiences.

[a]At the time of publication, the percentage of funding was targeted at multiple groups traditionally underrepresented in SMET and therefore could not be accurately attributed to any of the groups indicated here.

[b]Other underrepresented groups include geographically underrepresented groups, economically disadvantaged groups, and groups with limited English proficiency.

Figure 3

Distribution of Core Program Funding Targeting Underrepresented Groups

Improving Minority Access to Research Careers

In 1991, just 2.5 percent of science and engineering Ph.D.s were awarded to African Americans; Hispanics received only 3.3 percent. The Department of Health and Human Services' Minority Access to Research Careers program provides special research training opportunities and incentives to attract minority students to and retain them in the biomedical and behavioral sciences. The program assists minority institutions in developing strong undergraduate science curricula, in stimulating undergraduate students' interest in research careers, and in increasing the number of students pursuing careers in biomedical and behavioral science research. The program is comprehensive: it addresses different educational levels, from high school through undergraduate and graduate education, and faculty enhancement.

Invest in all people: **Federally funded programs must actively and continually seek ways to improve participation and retention of underrepresented populations and to make SMET accessible to all citizens.** Piecemeal programs will not work; we need comprehensive strategies that cross the various education levels to ensure that the educational system as a whole provides continuous support for equity goals. The Federal Government should collaborate with state, local, and private organizations to expand student support programs in SMET education, particularly among underrepresented groups. Funded programs must sustain students' confidence and aptitude throughout high school and beyond, encouraging movement from one educational milestone to the next.

1.2 *The Federal Government currently spends about $25 million on educational technology, distributed as shown in Figure 4. Federal funds support research and development on applications ranging from computer-based instruction to electronic information networks to CD-ROMs. Communications technologies such as computer networking, cable television networks, and satellite broadcasting have the potential to increase greatly—at all educational levels—the availability of and access to SMET educational programs and activities. Some of these capabilities are widely used by industry in training their employees. Despite the emergence of promising educational technologies, however, not enough is known about the settings in which they may be most effective.*

Invest in effective tools of discovery: **The Federal Government should support aggressive research, development, and evaluation efforts to determine the types of educational technologies that are most effective in different settings and in advancing different goals.** This research effort is essential to ensure the availability of a rich array of practical, effective source materials and technological tools and their appropriate uses at all educational levels, including adult and continuing education. Links between industrial capabilities in educational technologies and communication and SMET education needs should also be explored.

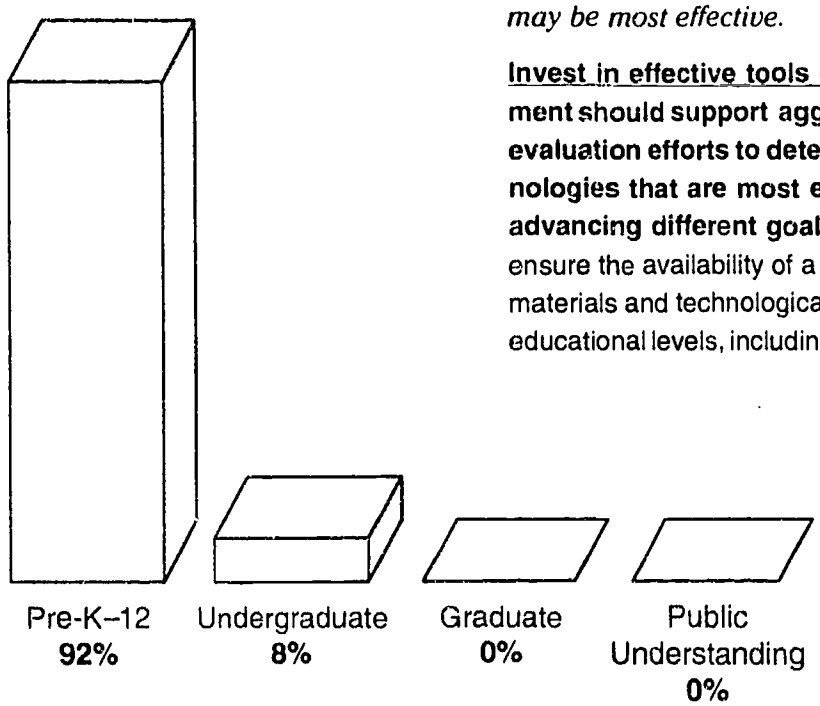


Figure 4

Distribution of Core Programs Funding for Educational Technologies

1.3 *Less than 1 percent of core Federal funding for SMET is allocated for dissemination. Valuable educational resources developed with Federal funding—including effective educational and instructional practices, quality curricula and other educational products, and information about those resources—have not been shared effectively. Furthermore, concise information about the availability of the many Federal programs for instructors and students is difficult to obtain. This situation is inefficient and costly and weakens the entire Federal program portfolio.*

One way to maximize the effect of SMET education resources is to improve dissemination. The Federal Government has not fully leveraged all of the available resources to support SMET goals. Often, Federal SMET education initiatives do not promote cooperation among the various segments of our society. Few effective alliances among Federal, state, and community partners have been formed.

a. Leverage the investment through leadership: **Federal SMET education programs should constructively exploit not only available funds but also existing programmatic resources and infrastructures when appropriate—personnel, training tools, data sources, and management information systems—across agencies, other governmental levels, businesses, and communities.** Such leveraging would allow the Federal Government to achieve its SMET education goals and reach its desired audiences more rapidly, efficiently, and cost-effectively. Leadership is especially important in promoting alliances among state and local agencies and community-based partners in disseminating—through multiple means—information about innovative practices that improve the depth and scope of general SMET literacy. Leadership is also important in encouraging a nationally held belief in the value and importance of SMET education.

b. Market the investment: **Aggressive, targeted dissemination of information relevant to particular audiences—on professional and student opportunities, curriculum reforms, research results, and implications for practice—should become the paramount feature of the Federal Government's commitment to demonstrating leadership in SMET education at all levels.**

1.4 *Little Federal funding (less than $15 million) has been allocated for the initial teaching preparation of instructors at all levels: pre-K–12 through graduate education, adult and continuing education, and public understanding of SMET. Preparation of pre-K–12 teachers often fails to include relevant research findings on learning and instruction, training in the use of educational technologies, or exciting new materials and curricula. Graduate students—many of whom serve as teaching*

"Every science agency of the government should have an explicit education charter defining its responsibilities to address precollege issues that lie within the agency's special technical expertise and human resource requirements."

Carnegie Commission on Science, Technology, and Government (1991)

Collaborating for the Dissemination of New Science Material

The Smithsonian Institution's National Science Resource Center fosters interagency collaboration by disseminating agency-developed instructional materials about teaching science through published guidebooks. The center is also developing a computer network to provide technical assistance to schools. In addition, the center complements efforts of the Department of Education and the National Science Foundation by disseminating resources produced with those agencies' support and by working in conjunction with their dissemination activities.

assistants or become college-level faculty—receive little, if any, formal professional education about effective teaching. This lack of emphasis on instructor preparation locks the nation into a continued, costly process of enhancing the skills of instructors who received inadequate initial preparation.

Invest in the future: **Funding should be reallocated to provide more support for teacher preparation programs at all levels.** Pre-K–12 SMET teacher preparation should include support during the critical first years of teaching careers. Programs to educate graduate students—as well as current college and university faculty members—about new developments in cognitive science and effective teaching strategies should be developed. Program guidelines should ensure that instructors in all educational areas are sensitive to diversity, including multicultural issues and language differences.

"If getting better schools means doing better what we now do, the job is relatively easy. But if it means living up to our rhetoric about what education should be, then the challenge is one of the greatest this nation has faced."

J. Goodlad, "Toward a More Perfect Union," *State Education Leader*, 1986, Vol. 5, No. 2

1.5 *Research on SMET teaching and learning can form the basis for reform in instruction, assessment of student learning, curriculum development, and other areas. Unfortunately, Federal funding is low (about $10 million in core funding) and is too concentrated in a limited set of research topics.*

a. Invest in learning what works: **Funding for SMET education research should be increased, and its focus should be broadened to include a wider range of research topics and learning contexts and the effects of both on SMET education practice.** Research should be directed toward determining what works for diverse groups and in nontraditional settings. Action research—making educational reforms through an iterative process of research and implementation of new approaches—can yield rich information about what works and does not work in actual educational settings.

b. Invest in knowledge sharing: **Federal programs should encourage the collaboration of SMET education researchers with those providing SMET education at all levels, as well as with those developing SMET education products.** Such a collaboration will ensure that current knowledge of SMET teaching and learning practice (including subject matter content) is incorporated into the planning and implementation of SMET education instruction and projects.

New Ways of Learning Engineering

Nearly 40 institutions across the country are engaged in a program of comprehensive, innovative, and systemic change in engineering education sponsored by the National Science Foundation. The Engineering Education Coalitions program is reforming the way engineering is taught and learned through the formation of coalitions of two-year colleges, universities, and minority institutions. Through joint activities, coalition members are seeking to improve the quality of U.S. undergraduate engineering education and to increase the number of engineering baccalaureates awarded to women and underrepresented minorities.

Building Strong Foundations: SMET Education in Prekindergarten Through Grade 12

In addition to the crosscutting issues identified in the previous section, the Panel addressed a number of issues specific to particular levels or functions of education, beginning with the important early years of learning. Science, mathematics, engineering, and technology education at the pre-K–12 level is marked by three distressing realities:

- Many teachers lack adequate understanding of content as well as knowledge of effective SMET teaching methods.
- Teachers with appropriate skills often lack the resources necessary to support effective instruction.
- Too many students spend insufficient time on science in the early grades—and even less time on technology or basic engineering concepts.

Many students take only the minimum required courses at the high school level. Although students tend to spend more time learning mathematics than science, engineering, or technology, the mathematics proficiency levels reached by many students are too low.

The basic goals of SMET education—which are, first, to provide opportunities for all students to develop SMET competencies that they can apply in real-world situations and, second, to motivate students from all backgrounds and both genders to aspire to careers in these fields—have not been well served by traditional programs of SMET instruction at any level. School programs should be promoting problem-solving techniques, conceptual abilities, and higher level thinking skills to all students, they should also be encouraging students to develop positive attitudes about SMET. To these ends, learning media, curricula, and instructional strategies should encourage students to participate actively in SMET-based learning processes and help them construct, integrate, and apply SMET knowledge to real-world situations. Resources and support systems should facilitate this type of instruction, and the students exposed to it should be able to develop not only a deeper understanding of concepts and processes but also the interest and motivation to pursue further study.

In addition to encouraging educators to spend more time on SMET in school, the Federal investment strategy should encourage greater student exposure to applied sciences, such as environmental or health sciences. Applied sciences integrate topics from varied SMET areas, and they help students understand the uses of scientific knowledge and methods in their everyday lives. Study of the methods and nature of technology is another relevant area often neglected in elementary and secondary curricula.

"Nontraditional education is a powerful way to motivate students and interest parents in the serious study of mathematics and science and to explode negative stereotypes of science and scientists."

Carnegie Commission on Science, Technology, and Government (1991)

Thirty-five percent ($770 million) of core Federal funding for SMET education in 1993 is being spent on pre-K–12 programs. As shown in Figure 5, Federal spending for these programs is divided among five principal areas.

- Teacher enhancement programs further the skills of teachers already in the workforce, while teacher preparation programs improve the education received by students planning to become SMET teachers. Together, these programs receive 51 percent (about $395 million) of the pre-K–12 portion of core Federal funding for SMET education, with most of these funds ($370 million) going to teacher *enhancement*. Only about $25 million is spent for SMET teacher *preparation*.
- Organization reform and comprehensive programs receive 17 percent (about $128 million) of core Federal funding for pre-K–12 programs. Organization reform programs are intended to stimulate change in many or all components of a system of SMET education, such as at the city or state level. Comprehensive programs include multiple components designed to address a variety of audiences.
- Student support programs receive 16 percent (about $121 million) of core Federal funding for pre-K–12 programs. These programs are designed to motivate students to pursue studies in SMET subjects by offering activities that demonstrate real-world applications and by providing direct financial assistance.
- Curriculum improvement programs receive 10 percent (about $74 million) of core Federal funding for pre-K–12 programs. These programs develop new or improved materials, courses, and curricula and provide funding to develop SMET education standards and techniques that assess student progress.
- Educational technologies programs receive three percent (about $23 million) of Federal funding for pre-K–12 programs. These programs seek ways in which communications and information technologies can enhance SMET education.

"A curriculum is more for teachers than it is for pupils. If it cannot change, move, perturb, inform teachers, it will have no effect on those whom they teach."

J.S. Bruner, *The Process of Education* (1977)

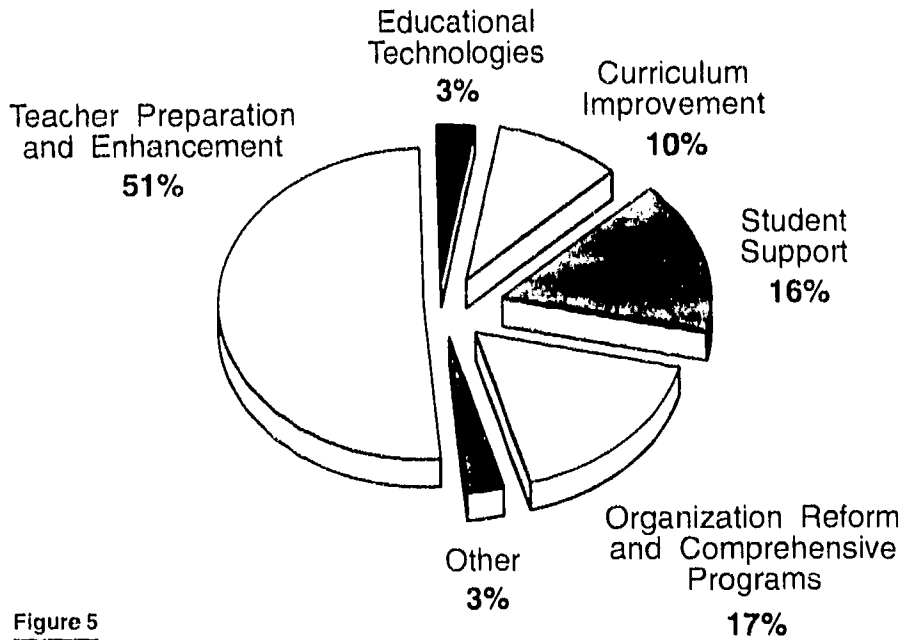


Figure 5

Distribution of Core Program Funding for Pre-K–12 by Functional Area

More than 80 percent of the funding for programs at the pre-K–12 level comes from the Department of Education and the National Science Foundation. Figure 6 illustrates the amount of funding that each agency provides for programs at the pre-K–12 level by functional area.

Findings and Recommendations

2.1 A substantial body of research-based knowledge exists on the characteristics of effective science and mathematics curricula and appropriate teaching strategies. National standards for curricula, teaching practices, and assessment techniques that reflect this knowledge are available for mathematics for pre-K–12 and are being developed for science.[3] Despite the progress being made in this area, curriculum development and teacher enhancement projects do not always draw upon relevant research about learning, teaching, curricula, and assessment. Such research is rarely stipulated as part of project design.

The Eisenhower Program: A Unique, Locally Based Resource

The Department of Education's Eisenhower State Mathematics and Science Education Program is the largest Federal program in pre-K–12 SMET education. For many school districts, Eisenhower "formula grants" (accorded to each district on the basis of its size) are the only support they receive for teacher enhancement and curriculum reform. Because school districts have local control over the disposition of these funds, they have considerable flexibility in responding to the needs of their constituencies.

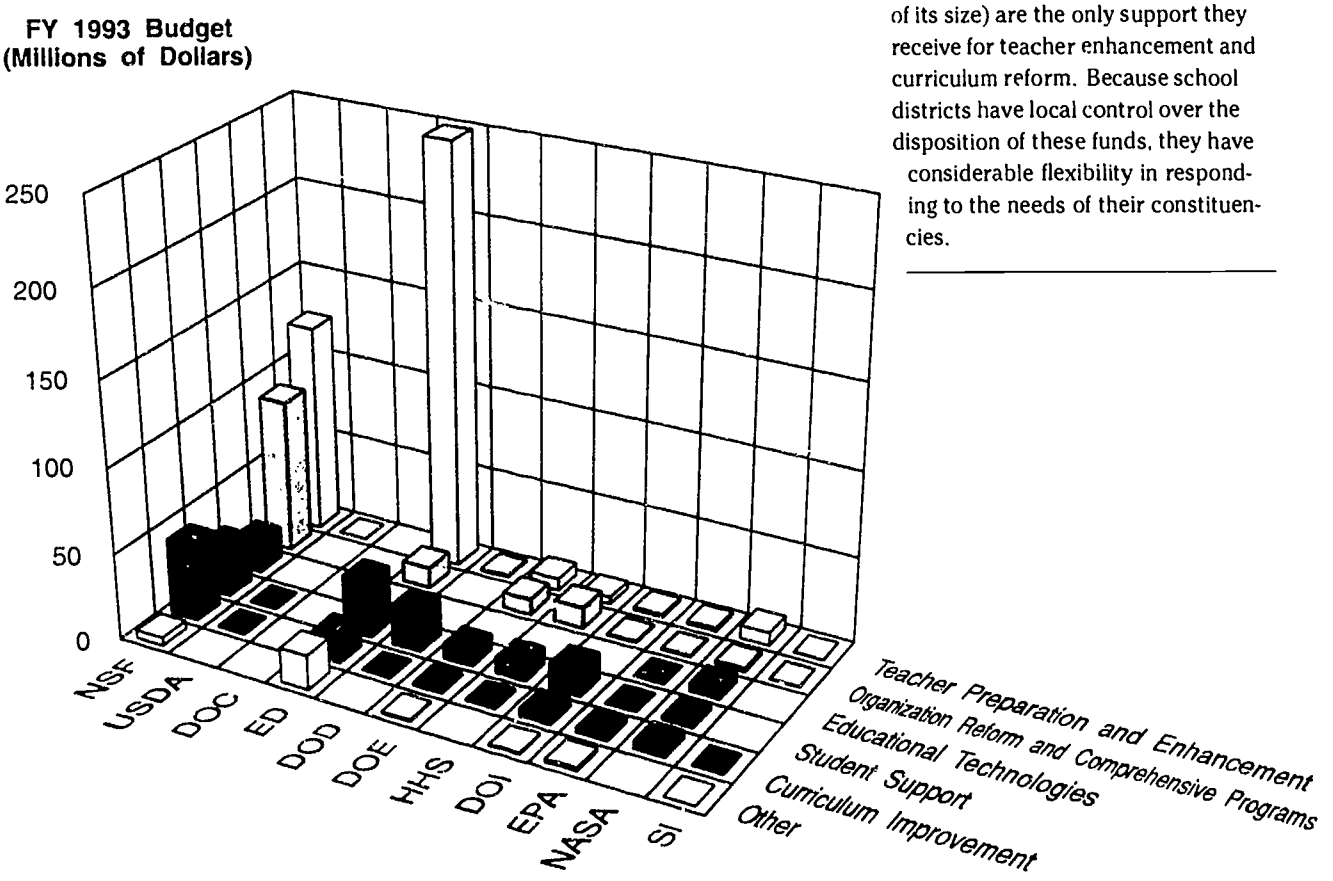


Figure 6

Core Program Funding for Pre-K–12 by Agency and Functional Area

[3]See *Curriculum and Evaluation Standards for School Mathematics*. National Council of Teachers of Mathematics Commission on Standards for School Mathematics (Reston, VA: National Council of Teachers of Mathematics, 1989) and *Professional Standards for Teaching Mathematics*. National Council of Teachers of Mathematics Commission on Teaching Standards for School Mathematics (Reston, VA: National Council of Teachers in Mathematics, 1991.)

Informal Science Education: Strengthening Classroom Learning

The National Science Foundation's Informal Science Education program uses nontraditional approaches to spark interest in science and technology in the classroom and among the public. Projects include media programs like "Square One TV," "3-2-1 Contact," and "Reading Rainbow"; permanent and traveling exhibits at museums and science centers; and after-school and weekend science activities for youth. To forge strong links between formal (classroom-based) and informal science education at the pre-K–12 level, curriculum experts develop materials to be used with educational television programs that complement the formal school curricula. Informal science educators often provide teacher in-service training on techniques for inquiry-based, hands-on science teaching. Also, museum exhibits incorporate classroom hands-on activities that reinforce school curricula.

Youth Conservation Corps

Since 1970, hundreds of thousands of students have participated in the Department of the Interior's Youth Conservation Corps. The program was designed to accomplish needed conservation work on public lands, provide employment for 15- to 18-year-olds of all social and economic backgrounds, and promote understanding and appreciation of the earth's environment and the nation's conservation heritage. The scientific and environmental knowledge gained by young people during the summer session builds on science and mathematics lessons learned during the school year and promotes self-discipline and the formation of team-building skills.

a. **Program guidelines should require that instructional materials and other projects developed for pre-K-12 reflect knowledge of research outcomes, practices, and standards specifically related to science and mathematics learning, attitudes, motivation, and instructional strategies. Collaboration among content area experts and instructional experts from all educational levels should also be emphasized.**

b. **All federally funded curriculum development and teacher enhancement projects should demonstrate—prior to funding—a viable plan for incorporating relevant SMET education research.**

2.2 *Federal teacher enhancement programs are designed to update and renew teacher knowledge of content and of appropriate curricula and teaching practices. An increasing number of programs are showing good multiplier effects by using lead teachers to provide education for other teachers. These excellent teachers expand their knowledge and mentoring skills and then, in turn, help their colleagues.*

However, teacher enhancement support is usually provided for one-time projects designed to "fix" a perceived problem. It is not clear how much follow-up takes place. Nor is it clear whether sufficient education is being delivered to groups whose knowledgeable participation in upgrading SMET opportunities and achievement is important for success (e.g., administrators, key board members, etc.). Efforts to bring together all of the diverse groups critical to implementing change are rarely required under existing programs.

a. **Teacher enhancement programs should be reformulated to emphasize the continuous enrichment necessary for excellence in SMET teaching, rather than being designed to "fix" problems.**

b. **Program guidelines should require the development and in-school support of teacher leaders to provide mentoring and education for their colleagues.**

c. **SMET programs should include awareness components for parents, administrators, school board members, and other community members. Better awareness among these groups will stimulate understanding of and commitment to SMET education and the investments needed to enhance SMET offerings.**

2.3 *Although some Federal education programs target SMET, other important opportunities are missed. Unfortunately, many currently funded Federal programs for children (e.g.,*

Head Start) do not include SMET education. Young children are naturally curious and eager to understand the world around them; early exposure to age-appropriate, inquiry-based science and mathematics curricula provides the foundation on which later understanding rests. For older children, this foundation can be expanded through direct experience with SMET activities.

Federal programs intended to provide additional support for low-income children (e.g., Chapter I and Head Start) should include rich early science- and mathematics-related experiences among the basic criteria required for funding.

2.4 *Technology itself is rarely a subject of study in our schools and colleges; even in science curricula, issues related to technology studies are barely mentioned. No Federal programs exist for the express purpose of promoting student learning about the nature of technology. Yet knowledge of the processes and methods of technology, as well as of the functions of technology in our society, could benefit all students and encourage more of them to pursue technologically demanding careers.*

a. **Funding should be provided to establish national goals for technology education and a curricular plan for their implementation. Such curricula, if implemented, would increase students' understanding of technology and encourage more students to pursue careers as technicians or engineers.**

b. **The Federal Government should fund curriculum improvement in the area of technology.**

Continuous Enrichment for Elementary Through College

The Mathematics, Engineering, and Science Achievement Program, which originated in California, engages students as early as the third grade. Students are continuously encouraged and assisted throughout high school to prepare themselves for college entrance. Although the Mathematics, Engineering, and Science Achievement Program is not a Federal program per se, it is supported in part by Federal funds and provides continuous support along the educational continuum by building alliances among schools, colleges, parents, and businesses.

Enhancing Our Base: Undergraduate and Additional Paths to SMET Education

Undergraduate SMET Education

A dramatic drop in SMET participation occurs in the nation's institutions of higher education. If this situation is to be improved, undergraduate educators in science, mathematics, engineering, and technology must overcome serious obstacles. Instructional improvements to meet the needs of our prospective teachers, lawyers, and business people as well as those planning SMET careers must be made.

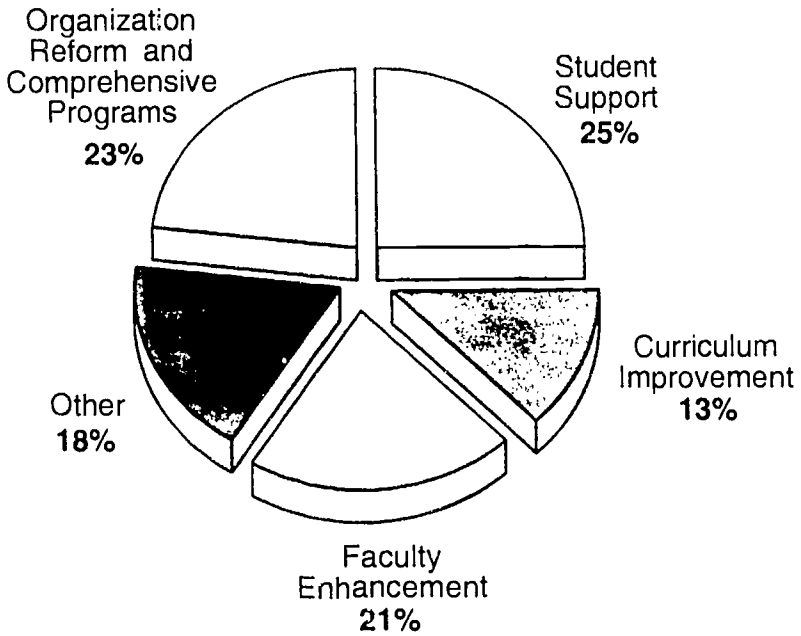
Although educators now know a great deal about effective learning and instruction, college instruction has changed only cosmetically during the last century. Traditional SMET teaching consists of lectures to passive and often disinterested students (especially among nonmajors). Sadly, far too many undergraduate science laboratory courses that should introduce students to inquiry and discovery, to the experimental paradigms of science, and to the uses of SMET knowledge fail to do so. In mathematics and the physical sciences, in particular, instruction often consists of doing repetitive textbook problems rather than teaching students to identify underlying concepts and procedures and helping them to apply their understanding in diverse contexts.

". . . the Federal Government can influence faculty priorities by giving more attention to curriculum development, instructional innovation, and effective teaching."

LEARNING to Meet the Science and Technology Challenge

Twenty percent of 1993 core Federal funds for SMET education are being spent at the undergraduate level (about $428 million). As shown in Figure 7, these funds are expended in four major categories.

- Student support programs receive 25 percent (about $108 million) of the undergraduate SMET funding. These programs provide research opportunities, financial assistance, and mechanisms to help students pursue SMET studies at more advanced levels.
- Organization reform and comprehensive programs receive 23 percent ($98 million) of Federal funding at the undergraduate level. Three-quarters of this funding is expended on comprehensive programs with multiple components for a variety of audiences. The remaining one-quarter of Federal funding is targeted toward organization reform programs that are designed to affect an entire system.
- Faculty enhancement programs receive 21 percent (about $92 million) of undergraduate SMET funding. These programs give college and university faculty members the opportunity to broaden their skills in research and subject matter knowledge. Faculty members can work with researchers on ongoing projects or attend seminars, institutes, and workshops on topics relevant to their disciplinary expertise.
- Curriculum improvement programs receive 13 percent (approximately $55 million) of Federal undergraduate SMET funding to reform undergraduate courses and curricula in SMET subjects.



Almost two-thirds of Federal SMET funding at the undergraduate level is provided by the National Science Foundation and the Department of Defense. Figure 8 illustrates the amount of funding that each agency provides for programs at the undergraduate level, by functional area.

Figure 7

Distribution of Core Program Funding for the Undergraduate Level by Functional Area

3.1 *Although more than $90 million is currently allocated to faculty enhancement programs, the vast majority of this Federal funding is targeted toward the improvement of research opportunities. Few mechanisms exist to support college faculty members seeking to redesign courses, learn about effective teaching methodologies developed for specific disciplines, or explore research findings on students as learners. Opportunities and incentives for undergraduate teachers to learn about teaching, learning, and curricula are not widely available.*

a. **Efforts to enhance college faculty should be expanded to reach many more faculty, and they should be redirected toward improving instructional practices and reforming curricula.**

b. **Federal programs must provide programmatic and monetary incentives that encourage colleges and universities to place a higher value on learning and instruction.**

Helping Undergraduate Faculty Improve Their Courses

The Department of Energy sponsors several small programs that pair undergraduate faculty with practicing researchers in Department of Energy laboratories to develop and improve undergraduate courses and programs in energy and environmental management. Faculty members spend a summer or an academic year at the laboratories to develop materials, including classroom and laboratory experiments, and to make other enhancements to the undergraduate courses they teach.

3.2 *Very few Federal programs provide funds for the improvement of undergraduate-level courses in SMET areas. Existing SMET undergraduate courses, especially at the introductory level, do*

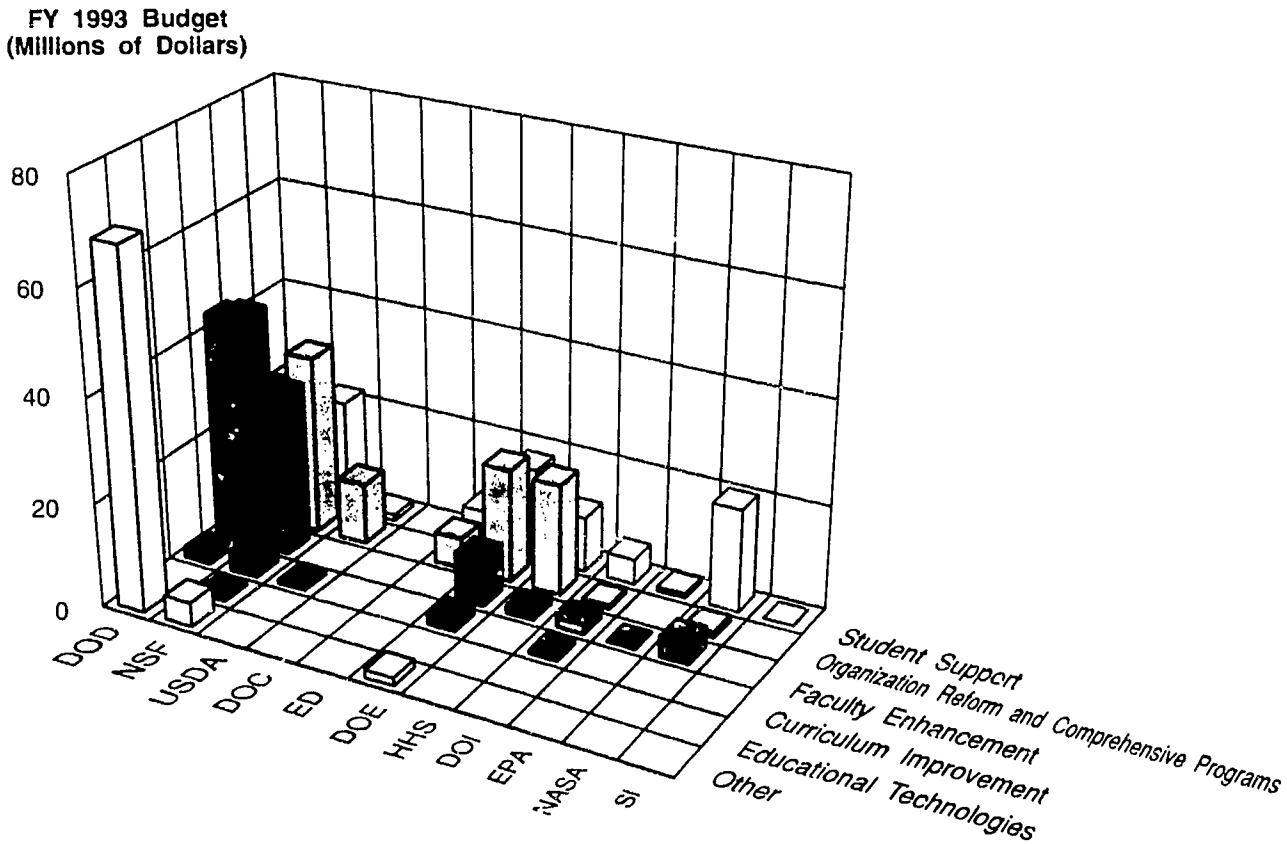


Figure 8

Core Program Funding for the Undergraduate Level by Agency and Functional Area

Improving Engineering Courses
Nearly 50 universities are supported by the National Aeronautics and Space Administration's Advanced Design Program which is reforming undergraduate study of advanced space and aeronautics engineering design through specially initiated courses and curricula. Originally conceived as a way to incorporate space and aeronautics topics into senior engineering courses, the program now also promotes interdisciplinary and cross-disciplinary topics and emphasizes the teaching of engineering design.

not reflect or keep pace with advances in teaching and learning nor with technologies and tools for problem solving. Furthermore, although institutions often add new courses at the advanced level to reflect new knowledge within a discipline, they are slow to recognize new disciplines and interdisciplinary areas. For students who do not intend to specialize in SMET areas—such as prospective elementary school teachers, lawyers, or business managers—courses rarely provide a clear appreciation of the methods of science and technology or enhance the ability of students to use these methods in their daily lives.

a. **Priority in curriculum improvement support should be given to programs that develop SMET courses for nonscience majors, especially in emerging disciplines or interdisciplinary fields.**

b. **Federal support guidelines for curriculum development should require that newly developed courses incorporate up-to-date knowledge about the discipline and effective ways to translate that knowledge to students.**

Community Colleges and Adult and Continuing Education

Since World War II, an extraordinary number of new opportunities for education and training in the sciences, mathematics, engineering, and technology have become available through community college and adult and continuing education programs. These programs serve a variety of functions and audiences, from those seeking basic SMET literacy to highly skilled workers seeking advanced training or recertification in their fields. The range of programs must continue to meet these varied needs.

Approximately 1,300 regionally accredited community, technical, and junior colleges serve more than five million students. In 1990, about 44 percent of the nearly 12 million undergraduate students in the United States were attending two-year institutions. The student population of these colleges is diverse racially, economically, and in student age. Only about one-third of two-year college students are preparing for transfer to four-year institutions.

Certification programs in technical fields, along with retraining for technical workers, are important services offered almost exclusively by two-year institutions. Industry and business partnerships involving shared facilities, donated or consigned equipment, and cost sharing have helped to keep two-year college programs at the forefront of technology training, while high school and four-year college and university programs have fallen behind. Many community college faculty are also practitioners who can offer students regular contact with the professional environments of their fields.

Adult and continuing education programs occur in a variety of venues, including employer-funded programs in the workplace, programs run by school districts or community colleges, and media programs. The Federal role in adult and continuing education has been minimal. The opportunity exists to do more, particularly in the area of making existing technical training programs more available, perhaps through distance learning networks.

4.1 *Community and junior colleges serve a much more diverse clientele than four-year colleges or universities. This diversity includes socioeconomic status, geographic distribution, and race and ethnicity. Nearly one-half of the students from groups underrepresented in SMET careers who are enrolled in institutions of higher education are enrolled in two-year colleges. Yet two-year institutions receive only six percent of core Federal funding for undergraduate SMET education.*

Federal funds should be used to encourage greater collaboration among two- and four-year colleges for improving programs that support nontraditional students and students who are underrepresented in SMET disciplines. Such collaboration would help to meet the specific needs of students from these groups and increase the number who pursue—and progress in—SMET fields beyond the two-year degree.

4.2 *Little Federal funding is provided for technical education or for the involvement of students of all ages in appropriate SMET industrial educational opportunities. Such opportunities include technical apprenticeships, related work experiences, and in-school technical training.*

a. **More mutually beneficial collaborations among high schools, two- and four-year institutions, and industry should be pursued. Federal funding should be used to encourage stronger information sharing and cooperation, especially with respect to curriculum development and student assessment methodologies. Such collaboration could provide students in four-year institutions with technical training opportunities that those institutions often do not have the capacity to offer.**

b. **Federal initiatives to strengthen occupational training in technical areas should encourage strong curricular linkages to relevant science and mathematics concepts.**

4.3 *Community and technical colleges fill important niches in our educational system as a whole, especially in the areas of worker training and continuing education. Industry relies heavily on*

Findings and Recommendations

Workforce Skills Standards and Competencies for a High-Performance Economy

The Department of Labor and the Department of Education are working on a major effort to improve the work readiness of our future labor force. Building upon significant contributions already made by business, labor, educators, and states to identify the skills and competencies needed by a world-class workforce, the two agencies are now developing a national structure to encourage the use of voluntary standards that will make these skills and competencies integral parts of a high-performance economy. The school and training program curricula resulting from this initiative feature new and wide-ranging technological applications as well as innovative classroom-workplace arrangements involving elementary, secondary, and postsecondary education levels.

Building Human Resources in Energy Technology

Several hundred minority students are supported each year under the Minority Honors Training and Industrial Assistance program of the Department of Energy. The program provides scholarship support, academic activities with college faculty, and other support that helps students develop knowledge and skills for careers in energy-related technical fields. The program fills an important niche in the labor force by bringing together several audiences: talented African American, Hispanic, and Native American students; community and technical college programs in energy technology; and local industry.

these programs and, in many instances, has developed mutually beneficial partnerships with community and technical colleges.

The Federal Government should play a more aggressive role in the continuing education of the technical workforce through such activities as providing models for duplication, funding appropriate research, and opening avenues for technical assistance.

Public Understanding of SMET

Americans must understand fundamental scientific and technological concepts if they are to live productive and healthy lives in a continually changing, technologically dependent society. The avenues through which public understanding of SMET may be improved and maintained are many and varied. Programs to serve decisionmakers, community-linked programs, media programs, and programs in museums all serve different public education functions. A diverse network of these and other resources is needed to help improve public understanding of SMET.

Programs that promote public understanding of SMET account for just three percent (about $67 million) of core Federal SMET education investment. These programs educate audiences of all ages about the impact of science and technology on society, about basic SMET concepts, and about the underlying principles, methods, and processes of SMET research. As is shown in Figure 9, 1993 Federal funding for public understanding of SMET is distributed in four areas.

- Public and community-linked programs receive 65 percent (about $43.5 million) of Federal funds set aside to promote public understanding of SMET. These programs incorporate science education into activities of daily life and promote better understanding of the importance of science and scientific research.
- Public information campaigns, which receive 13 percent (or about $8.7 million) of Federal funds set aside to promote public understanding of SMET, are specialized segments within larger public information campaigns and individual information sources that are specifically targeted toward increasing scientific knowledge and understanding of scientific principles.

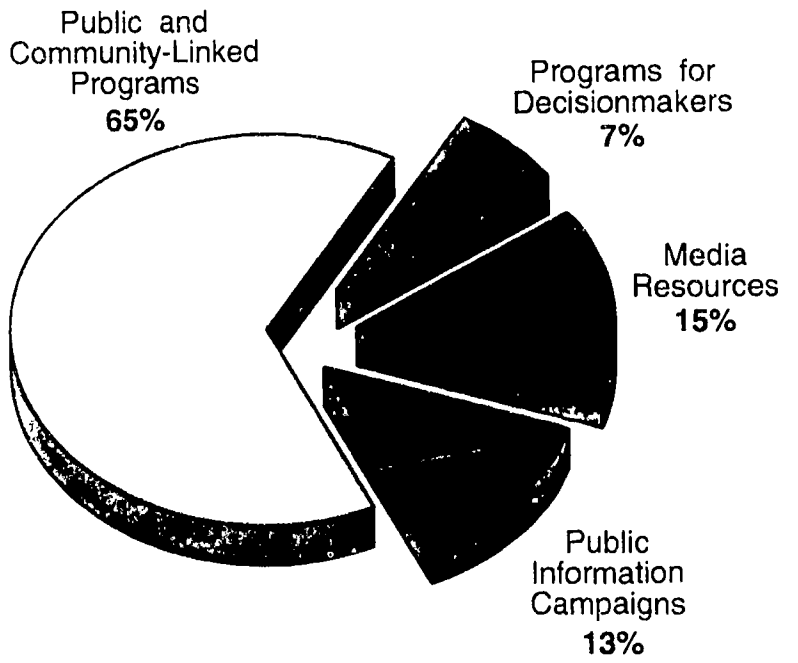


Figure 9

Distribution of Core Program Funding for Public Understanding of SMET by Functional Area

- Media resources receive 15 percent (about $10 million) of Federal funding dedicated to public understanding of SMET. The funds are used to provide scientific information to increase public awareness and knowledge and to help change the public perception of science.
- The remaining seven percent (about $4.7 million) funds programs for government, corporate, and media decision-makers. These programs help them understand scientific concepts, principles, and issues so that they will be able to make informed professional decisions.

Figure 10 shows that the Department of the Interior provides two-thirds of the funding for programs designed to improve the general public's understanding of SMET, with the Smithsonian Institution, the National Science Foundation, and the Department of Energy playing smaller but active roles.

Much remains to be done in increasing public understanding of and interest in SMET. Although society relies heavily on technology (indeed, most young children take computers for granted), positive images of the people who make and use technology are sorely lacking in popular culture.

"Knowledge of the humanities...must be harnessed to science and technology if the latter are to remain creative and humane just as the humanities need to be informed by science and technology if they are to remain relevant to the human condition."
A Nation At Risk

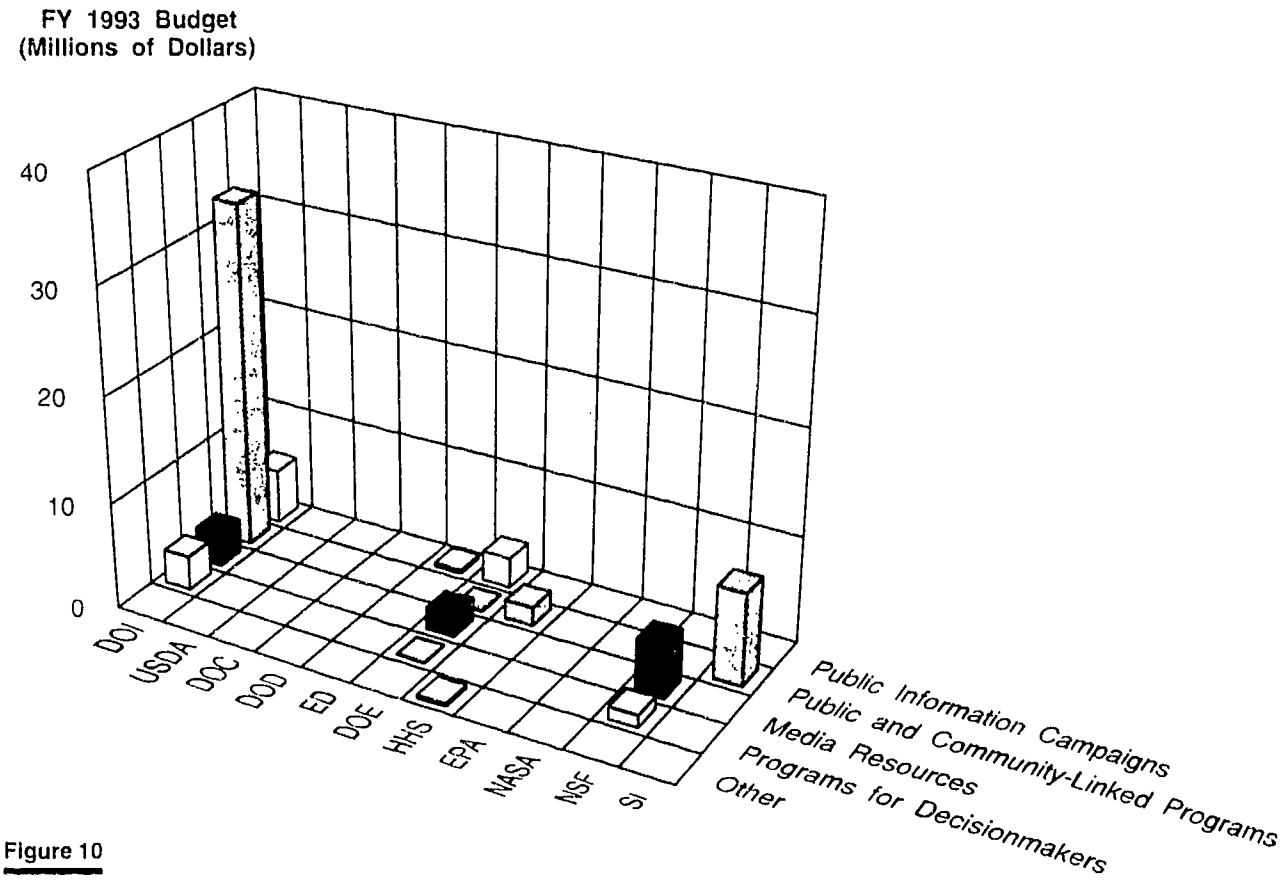


Figure 10

Core Program Funding for Public Understanding of SMET by Agency and Functional Area

Science Behind the Art of Nature
The National Park Service and the Fish and Wildlife Service (both of the Department of the Interior) use the nation's natural resources as the subject and as the classroom for their programs. At Yellowstone National Park, for example, visitors learn about the reintroduction of endangered species into wildlife and the implications of this process for local flora and fauna and for the ecosystem as a whole. At the Grand Canyon National Park in Arizona, exhibits highlight the geological principles behind the canyon's formation. These efforts foster public understanding and appreciation of nature and environmental science so that visitors can make informed, responsible decisions about environmental issues that will affect them and the generations to come.

5.1 *For some Federal agencies, enhancing SMET literacy and promoting positive public attitudes toward SMET study and work are relatively new endeavors. Certain federally funded programs straddle the line between public information and public relations efforts. While public relations programs can elicit much-needed funds, it is crucial that the public relations agenda not overwhelm the SMET education agenda. Overall, Federal efforts at public outreach are underfunded and unbalanced in terms of emphasis. Agencies lack knowledge of actual public needs, let alone knowledge of the best mechanisms for achieving greater awareness of SMET.*

a. **A coordinated, ongoing strategic planning process that utilizes needs assessments and evaluation to increase public understanding of SMET must be designed and implemented. Overall Federal priorities that strike a balance between different types of programs and support both large- and small-scale efforts as appropriate should be established.**

b. **The overall level of effort for public understanding functions needs to be increased and coordinated, particularly in high-impact areas such as media outreach.**

c. **Program priorities related to public understanding should clearly distinguish between public relations activities and SMET literacy efforts. Major efforts by any agency should be reviewed by nongovernmental experts in SMET and public literacy.**

5.2 *Federal collaboration with local and private-sector initiatives is limited, as is the incorporation of existing community-based efforts in Federal program planning. Lack of collaboration at the planning stage too often leads to duplication of programs and competition within communities or among institutions. Local expertise and credibility is necessary to ensure effectiveness and leveraging of programs.*

Federal programming initiatives should require links and coordination with private-sector efforts and with community-based programs.

Sharpening Our Expertise: Graduate SMET Education

The nation's graduate SMET education system has a reputation for excellence, and indeed, it produces researchers who are among the best in the world. Often, however, these excellent students learn despite, rather than because of, the teaching in their courses. Teaching at the graduate level suffers from many of the same problems as undergraduate teaching. Nor is the uneven quality of teaching the only problem affecting graduate education. The levels, depth, diversity, and preparation of the pool of U.S. applicants to graduate schools are also cause for concern. The reasons for this situation are not fully understood and need further investigation.

Graduate SMET education accounts for 42 percent (about $922 million) of core Federal funding for SMET education in 1993.

As can be seen in Figure 11, about 65 percent of Federal SMET funding at the graduate level is allocated to student support programs such as fellowships (financial awards made directly to students for academic support) and traineeships (awards made to institutions to support students). These student support opportunities are available to both predoctoral and postdoctoral students. More than 80 percent of Federal funding for graduate-level programs is provided by the Departments of Health and Human Services and Defense (see Figure 12).

Fellowships and traineeships play different roles; both can be used to target funds toward students from underrepresented groups and to promote fields perceived as areas of national need. However, because of the disjointed Federal resource allocation process and the lack of coordination among agencies, fellowships and traineeships—as well as other Federal mechanisms of graduate student support—suffer from the fragmented Federal approach to human resource development in SMET. Additionally, as currently administered, both of these funding mechanisms are slow to respond to labor market fluctuations. With increased dialogue among agencies, however, fellowships and traineeships can be transformed from primarily a student support tool to a mechanism that shapes and enhances the national human resource pool.

In addition to funding traineeships and fellowships, Federal dollars support graduate students through graduate assistantships for research grants. The amount of research grants that supports graduate students is difficult to determine because most agencies do not identify the portion of their research support that goes directly to students. The challenge for agencies

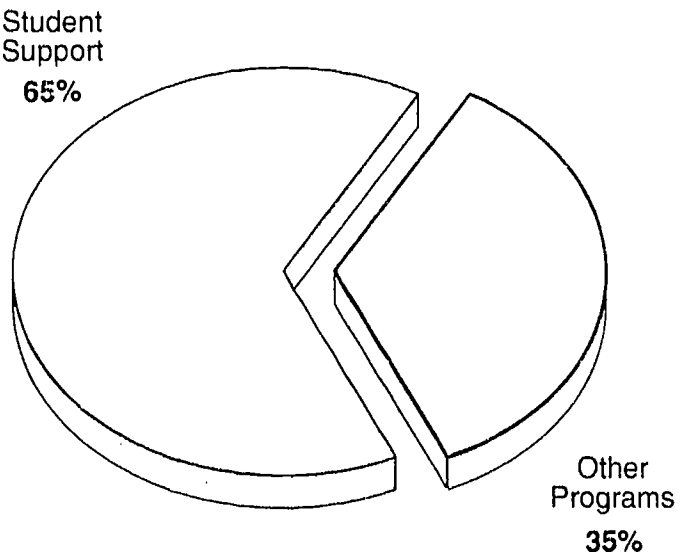


Figure 11

Distribution of Core Program Funding for the Graduate Level by Functional Area

funding competitive research grants is to ensure that the grants provide adequate education for the graduate students and do not encourage students to pursue fields of study in which employment prospects are limited.

Findings and Recommendations

6.1 The quality of graduate education is affected not only by the quality of the research program available to the student but also by a number of other factors. In large laboratories, students may seldom see their nominal supervisor and may receive little mentoring. Students can be exploited without receiving appropriate credit for their contributions. Currently, the totality of the graduate educational experience is neglected because of an overemphasis on the student's role as research assistant. The Federal Government is demonstrating inadequate leadership in addressing these system-wide problems.

Research program guidelines should require that proposals explicitly state the role of the grant in providing a well-rounded educational experience for the graduate assistants being supported.

Making Use of Unique Resources
The Department of Commerce's National Institute of Standards and Technology/National Research Council Postdoctoral Research Associateships program provides two-year fellowship appointments for outstanding scientists and engineers chosen through a national competition. The appointments provide an opportunity for the nation's best young scientists, mathematicians, and engineers to engage in state-of-the-art research in association with senior research specialists on the Institute's staff, utilizing excellent and often unique research facilities.

6.2 Students seeking a terminal master's degree, a professional degree (such as a master's in engineering), a teaching credential, or a Ph.D. degree in SMET education are rarely supported by the Federal Government through current fellowship and traineeship programs. However, people with these skills are crucial for our economic well-being.

Federal funding should be reallocated to provide more support for students in professional, applied SMET areas. Traineeship or fellowship opportunities in these areas should be augmented or developed to supplement existing Department of Education loan programs

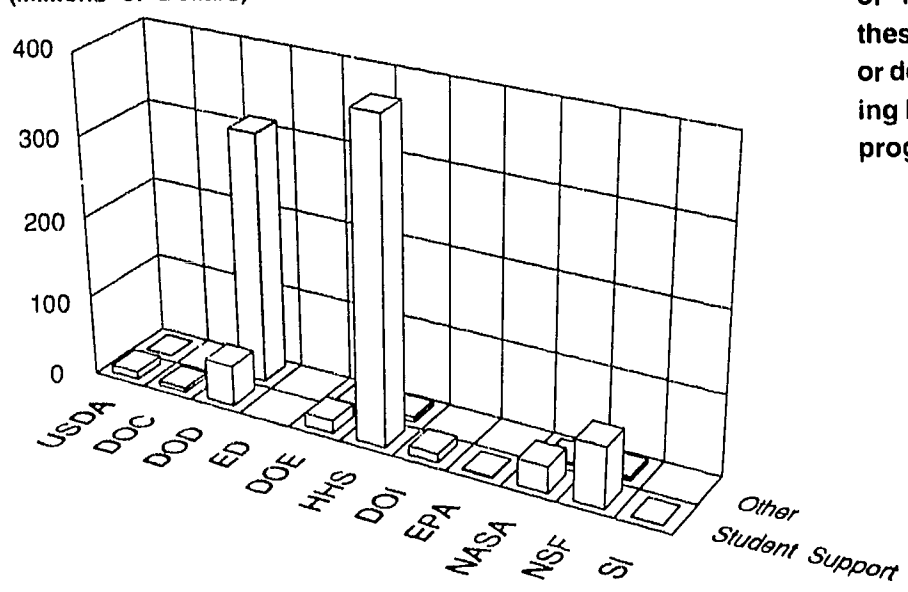


Figure 12

Core Program Funding for the Graduate Level by Agency and Functional Area

6.3 *Although considerable Federal funding is available for graduate study, the match between national labor force needs and the distribution of funds across SMET areas has not been systematically considered by the Federal Government.*

Agencies must collaborate to ensure that the availability and distribution of graduate student support is responsive to labor force needs and emerging and interdisciplinary fields of SMET rather than to idiosyncratic governmental funding patterns.

Addressing National Needs

Based on an extensive study of expertise-shortage areas in the food and agricultural sciences—and at the urging of business and industry leaders—the Department of Agriculture initiated a graduate traineeships program in 1984. It is the only Federal program targeted specifically to the recruitment and training of predoctoral students for critical food and agricultural scientific positions. Former Fellows today are making significant teaching and research contributions in their areas of expertise.

The Role of Evaluation

Evaluation is the process of systematically collecting and analyzing data to answer questions about the merit and worth of programs and their subparts. Evaluation is an essential part of sound management, vital to program decision making and to strategic planning for the optimal use of available resources. At present, however, evaluation of Federal SMET education programs is inadequate; consequently, the effects and effectiveness of the significant Federal investment are, to a large extent, unexamined. For a majority of Federally funded SMET education programs, no evaluation information is available at all (see Figure 13), or no serious inquiry beyond anecdotal or self-reported data has been made. This disturbing lapse must be addressed immediately. The Federal Government cannot continue to spend large sums of money without knowing if its programs are accomplishing their established goals—or if these goals address national needs in SMET education.

At a fundamental level, Federal programs lack a rational basis for strategic planning and decision making. For example, how much support for mathematics education is needed relative to science education? How much should be invested in pre-K–12 compared to other educational levels? What is a sensible strategy to accomplish public literacy goals? The Federal

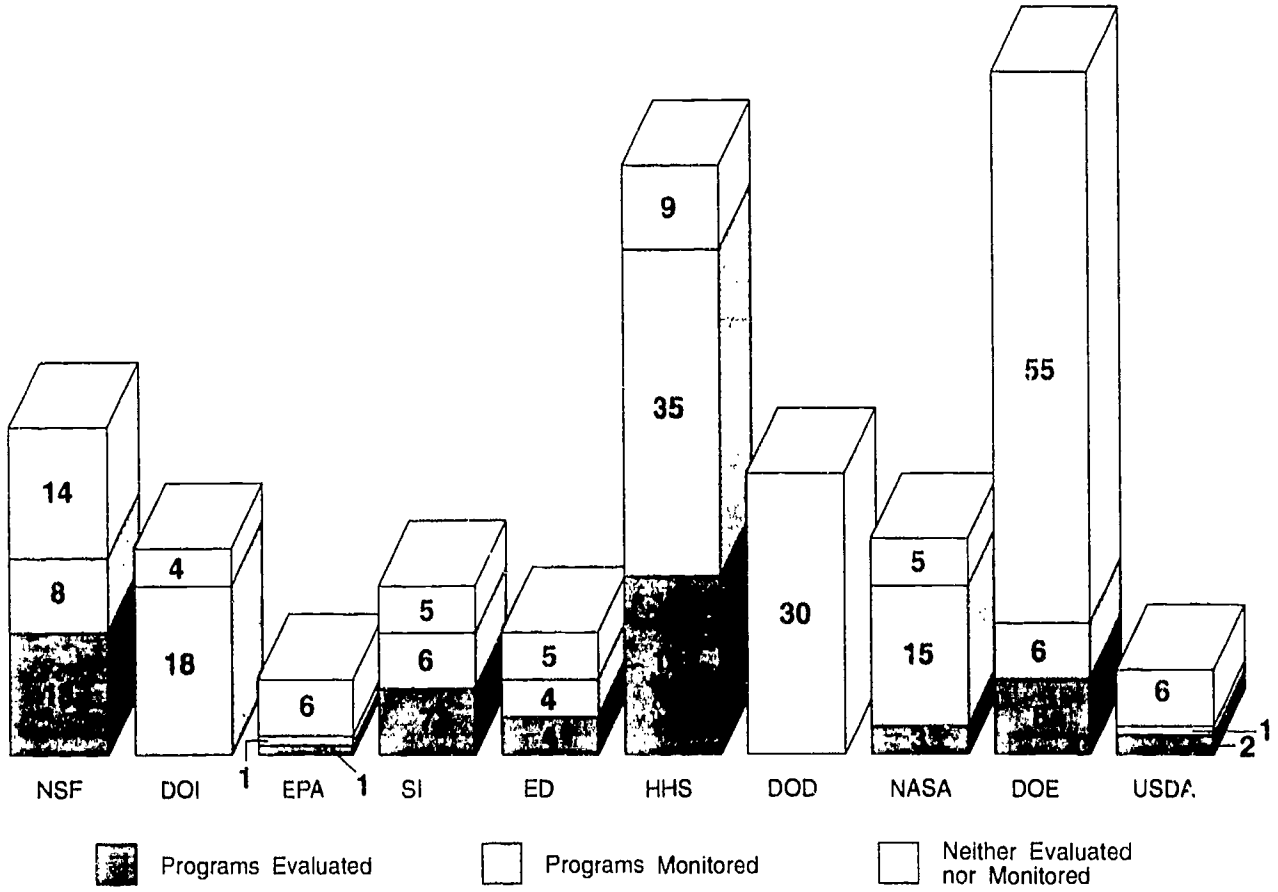


Figure 13

Number of Core Programs Evaluated or Monitored by Agency

"The Federal Government cannot continue to spend large sums of money without knowing if its programs are accomplishing their established goals—or if these goals address national needs in SMET education."
Expert Panel

Government lacks basic needs assessment data that would enable it to determine how much to invest and how the investment should be distributed across various agencies, fields, programs, strategies, and educational levels.

The size and complexity of many Federal SMET programs make rigorous evaluation a challenge. Assessing program effects on the target audience (e.g., improved pre-K–12 instructional practice that promotes access and learning for all students) requires both sophisticated methodological skills and substantial resources. Even in less complex programs, proper evaluation requires time and skill to collect and synthesize appropriate data to answer policy questions. Because so many agencies contribute to the accomplishment of broad goals, interagency coordination of evaluation efforts is critical.

It is clear that the Federal Government's evaluation practice suffers from insufficient resources needed to address these challenges adequately. Evaluation must be addressed in an interagency context. Problems to be resolved include fiscal considerations, mechanisms for cooperation, and educational provisions about evaluation. Many agencies lack the staff time, expertise, and capacity to design or monitor studies. In many cases where evaluations have been performed, agencies fail to consider the implications for program planning and improvement.

The development of a community within the Federal Government that values evaluation will encourage discussion, criticism, and promotion of evaluation activities in SMET education. Such a self-critical community will result in peer support, capacity building, and more successful evaluations.

Findings and Recommendations

7.1 The recently adopted Federal Strategic Plan for SMET education contains several vital program evaluation features:

- *Evaluations will be conducted in a continuous, multiyear cycle.*
- *Agencies will build the appropriate capacity to monitor evaluations.*
- *Evaluations will be coordinated and synthesized across agencies.*
- *An expert panel will advise the agencies.*

The evaluation component of the Federal Strategic Plan for SMET education must be implemented. The Evaluation Working Group of the interagency Committee on Education and Human Resources must continue to monitor and more actively coordinate evaluation of SMET education programs throughout all agencies.

7.2 *Current efforts to coordinate evaluation activities across agencies are progressing too slowly. More attention must be given to developing cost-effective evaluations as well as an interagency capability to conduct major evaluation initiatives.*

a. **All agencies should show evidence of significant progress in planning and implementing evaluations by the end of fiscal year 1994.**

b. **Evaluation efforts must be prioritized and combined across agencies to not only make the most efficient use of existing funds but also allow examination of the whole Federal portfolio in terms of progress, balance, and responsiveness to changing needs. It may be possible to develop template or prototype evaluation designs that would streamline some of the evaluation process. Agencies with expertise in evaluating particular types of programs should be designated to take the lead in developing common evaluation designs.**

7.3 *The quality, extent, and timeliness of evaluation practice vary substantially. Although evaluation design obviously depends in part on the nature of the programs themselves, and although no single set of methodologies or techniques will be appropriate for every type of evaluation, agencies and programs must nevertheless meet standards of good evaluation practice.*

Federal agencies should implement standards of evaluation practice, using as a base those standards currently being revised by the Joint Committee on Standards for Educational Evaluation, a coalition of 15 professional organizations concerned with the quality of evaluations.[4] Several concerns are especially relevant with regard to the setting of such standards.

- **Evaluations should be designed to minimize demands on project participants. Strategies that require all participants or all recipients to respond to extensive data collection procedures should be minimized.**
- **Timeliness is essential for evaluation studies whose results are expected to inform Government policy makers. This fact requires that current governmental clearance processes be accelerated.**
- **Information on costs and cost comparisons is critical to sound evaluation. A cost-benefit perspective should be maintained both for programs and for evaluations.**

A Novel Approach to Program Improvement

The Department of Energy, its National Laboratory education staff, and the National Center for Improving Science Education are designing and implementing an evaluation of the Department's elementary and secondary SMET education programs. This is a unique, capacity-building effort that is designed to determine what practices work best under which circumstances and how those practices can improve program quality. Different from traditional designs, the evaluation contains the following components:

- Templates for each program type to assess the extent to which best practices are being achieved. The templates will help program staff identify areas for improvement.
- Evaluation and assessment tools that can be used by other agencies and the private sector when implementing similar programs.
- A capacity-building model that can identify issues not anticipated when the program was originally designed.

[4] See *Standards for Evaluations of Educational Programs, Projects, and Materials*, the Joint Committee on Standards for Educational Evaluations (New York, NY: McGraw-Hill, 1981).

■ **Evaluations should be designed with appropriate attention to the needs assessment that justifies the program.**

7.4 *Because programs and the influences on them are complex, evaluations must examine the nature of the programs themselves as well as all intended and unplanned outcomes over extended periods of time. This is true for evaluations at all levels, from local projects to projects that cut across Federal agencies. At present, Federal agencies lack a systematic perspective on evaluation that would allow them to revise programs on the basis of assumptions, evidence of redundancies or gaps, or the clarification and validation of effective models.*

Evaluations within and across programs should be based on a systems view, a view that considers key factors and influences on program operation and on short- and long-term outcomes. Furthermore, evaluations should encourage the identification and dissemination of exemplary practices and should provide those who implement programs with information to help them upgrade their programs.

7.5 *Student learning is the ultimate target of a majority of SMET programs. Recent studies have shown that the vast majority of SMET achievement tests focus on the recall of factual knowledge rather than on analytical reasoning or problem solving ability. Similar problems are evident in student assessment methodologies. Indeed, the overall Federal ability to affect SMET education has been hampered by inadequate student assessment methodologies.*

A comprehensive, cross-agency research plan is needed to explore the types of assessment required for a SMET curriculum that fosters critical thinking and to measure the effects of such a curriculum.

7.6 *Time, staff, expertise, and funds are inadequately allocated to the evaluation tasks at hand. Good evaluation requires a generous yet judicious commitment of resources.*

Funds for evaluation should be priority budget items for Federal agencies and for the projects they support. Additionally, time for learning about how to conduct evaluations and for reviewing, synthesizing, and implementing evaluation results should be made available to Federal agency staff.

Evaluating Complex and Large-Scale Approaches to Education Reform

The National Science Foundation has initiated a long-term project to evaluate the effectiveness of the complex and large-scale Statewide Systemic Initiatives program. Created in 1991, the program is working to reform the way K–12 science and mathematics is taught and learned in 25 states across the nation. The National Science Foundation is taking a multifaceted approach to evaluating the program's effectiveness. In addition to each state-level evaluation, the National Science Foundation will perform up to 10 case studies, will build a system of statistical indicators of program performance, and will implement a pilot survey of teachers to help determine the classroom-level effects of the program. The National Science Foundation is also providing technical assistance to help states implement sound approaches to science and mathematics education reform and program evaluation. Representatives from each state initiative meet periodically to share their plans for evaluation and to build upon what they have collectively discovered.

Assessing Mathematics and Science Education

The Department of Education is developing an overall plan to assess its mathematics and science education programs through monitoring and evaluation activities. The National Academy of Public Administration has assisted in this effort by developing suggested performance measures for the Eisenhower State Mathematics and Science Education program, a formula grant program designed to improve the skills of teachers and the quality of instruction in mathematics and science education in grades K–12. The Department of Education plans to use the development of performance measures for mathematics and science education as a model to guide future development of performance measures for all program areas.

7.7 *Many Federal agencies currently collect "indicators" to monitor program operations. Indicators are statistics about programs and their impacts; as such, they do not substitute for proper evaluation. However, indicators do play a role in program monitoring. They also aid in developing a culture of evaluation that focuses on high-priority outcomes and means of attaining them. Unfortunately, there is no agreed-upon set of indicators across agencies; each agency has its own way of collecting statistics.*

a. **Evaluation designs across agencies should include a minimum core set of indicators to be collected and synthesized (in conjunction with other information) by program managers for similar types of programs.**

b. **When indicators are used, they must be augmented by objective, systematic evaluation studies.**

c. **Federal data collection efforts must not overburden local programs but must encourage local programs to use the collected information for program decision making.**

Developing a System of Indicators to Improve Programs

The National Aeronautics and Space Administration (NASA) is working with the National Research Council on an 18-month project to develop indicators for the evaluation of NASA's education programs. The objective of the study is to raise the quality of data collection, which will ultimately help to improve the programs. The project is advised by a seven-member panel of experts in social and behavioral science, occupational research, education research and practice, and database construction.

As it reviewed the many Federal initiatives in science, mathematics, engineering, and technology at all educational levels in this country, the Expert Panel was struck by the energy and commitment of the Federal agencies and countless individuals. Across the nation, many positive efforts are making a difference in education. In terms of Federal activities, the Federal Coordinating Council for Science, Engineering and Technology Committee on Education and Human Resources stands as a potentially important agent for continued, constructive change in SMET education, and numerous Federal agencies are sponsoring positive reforms in SMET education. In addition, many talented people—educators, students, parents, business people, community leaders—are actively involved in bringing about positive change in SMET education.

Yet, as the Panel reflected on the decade that has passed since the publication of *A Nation At Risk*, it confirmed that much remains to be done to strengthen and redefine the Federal role in SMET education. Too many Americans know virtually nothing of the mathematical and scientific concepts and discourse (to say nothing of the technologies) that enrich contemporary culture, social experience, and economic progress. Ill-equipped to participate in important policy decisions in fields such as environmental and health science; surrounded and often overwhelmed by automated information, production and distribution, and communications systems; and unnerved by ecological, public health, and other social problems for which science and technology seem to lack ready solutions, average Americans are losing confidence in the value of scientific and technological perspectives.

It is the strong view of this Panel—after listening to the testimony of concerned, committed individuals at various Federal agencies—that a basic change in the way in which Federal agencies view their roles is needed. It is time for a new culture of interaction, communication, and coordination to be developed and sustained within and among all the agencies in the area of education. This new culture will necessitate flexibility in approaches to program design, development, implementation, and evaluation. Even well-coordinated programs may need to be revised to respond to changing external factors, such as new technological developments and work force needs. Change will also come in response to evaluation results. In the view of the Panel, it is within the agencies' power to effect such a culture change—but to do so, the agencies will need the fiscal and management support of Congress and the White House.

In summary, the Panel found that today's Federal programs in SMET education continue to be burdened by a lack of coordination, a lack of evaluation, and a lack of accountability. The Federal portfolio of investments in SMET education needs a comprehensive, coordinated management plan to provide balance and coherence across and within Federal agencies, other levels of government, and all areas and levels of SMET education.

Conclusion

"The people of the United States need to know that individuals in our society who do not possess the levels of skill, literacy, and training essential to this new era will be effectively disenfranchised, not simply from the material rewards that accompany competent performance but also from the chance to participate fully in our national life."

A Nation At Risk

"America's position in the world may once have been reasonably secure with only a few exceptionally well-trained men and women. It is no longer."
A Nation At Risk

Furthermore, programs must be evaluated more rigorously and consistently, and the evaluation information must be used more effectively.

It is the hope of the Expert Panel that the recommendations presented in this report stimulate future program coordination, development, and consolidation; reallocation of funds; and implementation of evaluation studies that provide the information necessary for making an informed investment in SMET education.

Appendix: About the Expert Panel

"We are deeply concerned about the lost potential represented by undeveloped talent for science, mathematics, engineering, and technology in America."

LEARNING to Meet the Science and Technology Challenge

The findings and recommendations detailed in this report are the work of an Expert Panel convened by the Federal Coordinating Council for Science, Engineering and Technology (FCCSET) Committee on Education and Human Resources (CEHR). Through eight committees, FCCSET coordinates policy for scientific and technical issues that affect more than one Federal agency. The membership of FCCSET consists of Federal departments and agencies with science and/or technology missions and is coordinated by the White House Office of Science and Technology Policy.

In January 1993, CEHR issued a Strategic Plan based on two years of coordinated interagency effort.[1] The plan addresses the well-being of science, mathematics, engineering, and technology (SMET) education at all levels and in all sectors. The plan describes the Federal Government's five-year planning framework and associated milestones that will focus the resources of the 16 participating agencies toward improving SMET competence among all students. The plan recognizes the importance of program evaluation for measuring results, ensuring accountability, and strengthening programs.

The CEHR Strategic Plan also calls for the creation of an Expert Panel to provide advice and recommendations on Federal SMET education programs and program evaluation. The National Science Foundation was given the responsibility to support and direct this activity. It is expected that this report of the Panel will be used in the Federal Government's five-year planning cycle and in shaping the future activities and directions of CEHR in program evaluation, program planning, and operation.

Nominations for Expert Panel membership were accepted from the participating agencies of FCCSET CEHR. More than 60 nominations were received in five professional categories: scientists, mathematicians, and engineers; education researchers; education administrators; education practitioners; and program evaluators. Of the 60 nominees, 15 panelists were recommended to CEHR by the National Science Foundation. Panelists were selected based on their breadth of experience, past accomplishments, reputations for excellence, and acquaintance with the Federal science, mathematics, engineering, and technology education enterprise. Panelists were also selected to ensure balance in gender, race/ethnicity, disciplinary background, education level of interest, and geographic distribution. Recommendations for Panel membership were approved by FCCSET CEHR and its Evaluation Working Group. Drs. Karl Pister and Mary Budd Rowe, who were named Panel co-chairpersons, served with the 13 additional panelists. Biographies of the panelists follow.

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[1] *Pathways to Excellence: A Federal Strategy for Science, Mathematics, Engineering, and Technology Education, U.S. Science, Mathematics, Engineering, and Technology Education Strategic Plan, FY 1994–FY 1998* Committee on Education and Human Resources (Washington, D.C.: Federal Coordinating Council for Science, Engineering and Technology Committee on Education and Human Resources, January 6, 1993).

Biographies

Karl Stark Pister, Co-Chair, Expert Panel; Chancellor, University of California, Santa Cruz; and formerly Dean of the College of Engineering, University of California, Berkeley, is chairman of the Board on Engineering Education for the National Research Council. Dr. Pister is a member of the National Academy of Engineering.

Mary Budd Rowe, Co-Chair, Expert Panel; Professor of Science Education, Stanford University, is past president of the National Science Teachers Association and formerly a chairperson for the American Association for the Advancement of Science (AAAS). She is now serving on the Council and the Committee of Council Affairs of AAAS. Dr. Rowe produced the first CD ROM available for science education, *Science Helper K–8*.

Stephen C. Blume, Elementary Science Specialist, St. Tammany Parish Public Schools, Slidell, Louisiana, is past president of the Society of Elementary Presidential Awardees and author and co-author of elementary and middle school science textbooks and curricular materials. He was a recipient of the National Presidential Award for Excellence in Science Teaching, 1990.

Patricia Chavez, Statewide Executive Director, New Mexico Mathematics, Engineering, Science Achievement (NM MESA, Inc.), is responsible for overall administration and advancement of New Mexico's successful precollege mathematics, engineering, and science achievement program. She is also the National Vice President for the National Association of Precollege Directors, a member of the American Association for the Advancement of Science, and a member of the Mathematical Science Education Board.

Ronald L. Graham, Adjunct Director of Research at AT&T Bell Laboratories, is one of the world's leading combinatorial mathematicians. He is President of the American Mathematical Society and Professor of Mathematical Sciences at Rutgers University.

Joan L. Herman, Associate Director, National Center for Research on Evaluation, Standards and Student Testing at UCLA's Graduate School of Education, is the author of *Tracking Success: A Guide for School-Based Evaluation* and the editor of *Making Schools Work for Underachieving Minority Students*.

Ernest Robert House, Professor of Education and Director of the Laboratory for Policy Studies at the University of Colorado, Boulder, is the author of *Professional Evaluation Social Impact and Political Consequences*. He is the winner of the Lazersfeld Award for Evaluation Theory in 1990 and the Harold D. Laswell Prize awarded by *Policy Sciences* in 1989.

Jacquelyn S. Joyner, Mathematics Instructional Specialist K–12, Richmond, Virginia, Public Schools, served as a member of the National Advisory Board, Macmillan/McGraw Hill, and was commissioned by the National Center for Educational Statistics to write a paper on the mathematics items of the National Assessment of Education Progress (NAEP) examination for 1991.

Floretta Dukes McKenzie, President of The McKenzie Group, a comprehensive education consulting firm, was formerly supe tendent and Chief State School Officer for the District of Columbia Public Schools. In the spring of 1990 and 1991, Dr. McKenzie was a distinguished visiting professor at Harvard University's Graduate School of Education. She is presently Distinguished Urban Educator-in-Residence at The American University, Washington, D.C.

Jose Mestre, Professor of Physics at the University of Massachusetts, Amherst, specializes in cognitive processes pertaining to learning science and mathematics and is co-author of *Academic Preparation in Science*. He has served as chair of the College Board's Sciences Advisory Committee and on various national boards, such as the National Research Council's Mathematical Sciences Education Board.

Wendell G. Mohling, Teacher and Outdoor Laboratory Director at Shawnee Mission Northwest High School, Kansas, is the NASA Space Ambassador from Kansas and a member of the International Faculty for the Challenger Center. He was the 1992–93 President of the National Science Teachers Association and is a former director of the National Science Teachers Association High School Division.

Michael James Padilla, Chair, Department of Science Education, University of Georgia, is an author of numerous articles and books on science teacher education. He has been appointed by the National Science Teachers Association to various boards of the National Council for the Accreditation of Teacher Education and currently leads the Georgia Statewide Systemic Initiative.

Helen R. Quinn, Senior Staff Scientist and Assistant to the Director for Education and Public Outreach, Stanford Linear Accelerator Center, is a fellow of the American Physical Society (APS), has served on the APS Panel on Public Affairs, and is President of the nonprofit Contemporary Physics Project.

Michael Scriven, Consulting Professor, Stanford University Graduate School of Education, is a Senior Fellow sponsored by the American Educational Research Association and the National Science Foundation. He publishes, teaches, and provides consultation in a broad range of disciplines in both the physical and the social sciences. He is the editor and author of numerous publications including *Evaluation Models* and the *Evaluation Thesaurus*.

James G. Wingate, Vice President for Programs, North Carolina Community Colleges, is coauthor of *Fundamentals of Probability* and has been actively involved in the Fund for the Improvement of Post Secondary Education, the National Association for Institutional Research, and the American Association of Community and Junior Colleges.

Frances Lawrenz, Special Assistant to the Panel Co-Chairs and Professor, Director of Graduate Studies in the Department of Curriculum and Instruction at the University of Minnesota, is the author of many articles on science education. She has conducted numerous evaluations of science programs. She served twice as a visiting scientist for program evaluation at the National Science Foundation.

Panel Process

The Panel conducted its deliberations through three two-day meetings, with work continuing in the intervening time. The meetings provided the opportunity to discuss issues and to meet with agency representatives to clarify understanding of each agency's programs. Panelists focused their deliberations on Federal SMET education core programs.[6]

The Panel used existing materials provided by the agencies and FCCSET CEHR. Those materials included—

- Relevant plans and strategies provided by each agency and FCCSET CEHR.
- One-page statements on each program.
- A matrix of programs, budgets, and audiences affected.
- Written and oral briefings by each agency and FCCSET CEHR representatives.
- A matrix and supporting narrative on the evaluation projects of each agency.
- Evaluation reports and program audits.
- Other publications, reports, and guides.
- Curriculum materials.
- Sample surveys.
- Program guides and inventories.
- Information about the condition of SMET education in the United States.

"All who have meditated on the art of governing Mankind have been convinced that the fate of empires depends on the education of their youth."

Aristotle

The Panel was divided into three five-member subpanels, each with responsibility for reviewing the activities of a subset of the agencies in greater detail. The subpanels were chaired by the evaluation specialists on the Panel: Joan Herman, Ernest House, and Michael Scriven. Subpanel members were assigned one of five topical areas to discuss with their counterparts from the other subpanels. The five areas covered were elementary and secondary education, undergraduate education, graduate education, public understanding of science, and program evaluation. These teams helped to summarize Panel discussions of the topical areas, ensuring coverage of all agencies within the topical groups. All Panel members were actively involved in the deliberations, and the final report represents the consensus of Panel members.

[6] The panel members also considered Federal support for programs contributing to SMET education although not explicitly designated or managed as such.

Agency Participants

Of the 16 FCCSET CEHR agencies, 13 participated in Expert Panel activity.[1] All FCCSET CEHR agencies with congressionally appropriated programs for SMET education or programs explicitly managed as such (core programs) participated in Panel activity. Each of the participating agencies was represented during Panel deliberations by its FCCSET CEHR Evaluation Working Group member. Panel members wish to gratefully acknowledge the dedication and hard work of the Evaluation Working Group participants, which made this report possible.

Department of Agriculture (USDA)
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Department of Commerce (DOC)
Carol Ann Meares

Department of Defense (DOD)
Robert Lockman

Department of Education (ED)
Nancy Loy and Rick Davis

Department of Energy (DOE)
Margaret Dwyer and Talitha Powell

Department of Health and Human Services (HHS)
Patricia Hoben

Department of the Interior (DOI)
William Mehojah and Larry Cardwell

Department of Labor (DOL)
John Heinberg

Department of Transportation (DOT)
Jocelyn Stevenson

Environmental Protection Agency (EPA)
Ronald Slotkin

National Aeronautics and Space Administration (NASA)
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Kenneth J. Travers, Conrad Katzenmeyer,
and James S. Dietz

Smithsonian Institution (SI)
Ann P. Bay

Executive Secretary, FCCSET CEHR
Angela M. Phillips

Director, Expert Panel Project
James S. Dietz

[1] Although members of FCCSET CEHR, the following agencies have no explicitly appropriated (core) programs in SMET education and did not participate in the Panel: the Department of Housing and Urban Development (HUD), Department of Justice (DOJ), and Department of Veterans Affairs (VA).